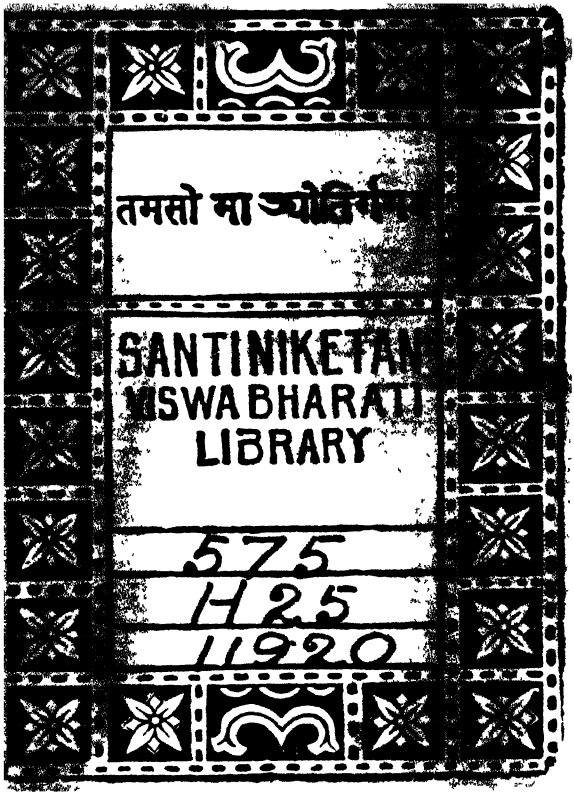
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PHASES OF
EVOLUTION AND HEREDITY

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BY

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Darwin and Weismann

"Before Darwin, the theory; after Darwin, the factors."

H. F. OSBORN.

"The idea of Evolution is the most potent thought-economising formula which the world has yet known, but as to the factors in Evolution we are still only inquiring."

J. ARTHUR THOMSON'S *Darwinism and Human Life.*

I

Darwin and Weismann

EVOLUTION, as the great process of life in this world and in the mechanism of the universe, is either openly or tacitly admitted by every one, not blinded to it by traditional error, that unfortunate heritage of all generations of mankind.

Darwin[1a] first brought this question to the serious consideration of mankind by his great investigation on the Origin of Species. Before him, orthodoxy, both in science and theology, had treated the question of the Origin of Species and of man, by any process other than that of direct creation on the sixth day, as matter for sport and ridicule; and Bridgewater scientists and eloquent

[a] Letters refer to a footnote; figures, to the Notes at the end, p. 245.

Episcopal wits vied with each other in laughing down Evolution.[2] It is not the least of Darwin's services that he changed all this, and the orthodox recognized that it was really to be a stern combat, and that they had opponents in earnest and not to be trifled with.

The modern idea of Evolution is a great generalization of Darwin's view of the Origin of Species, applied to the universe and all that is in it. Heredity is its restriction to the variation and transmission of characters in the individual plant or animal. Darwin's work was first applied[3] to the inter-relations of species; it has broadened out in its conception in Evolution, and in Heredity it is limited to a process in the organism. These only differ in their field of application, and not in their essential mechanism.

The explanation of the mechanism of Evolution in its various fields, how it acts, is, however, quite another matter, and it is here that evolutionists are at variance and even in violent opposition. Biological science, as well as its sister-subjects theology and

philosophy, has unreasonable votaries, men who contend, not for the nearest possible approximation to the truth, but for their own partial view of it and that of their school—quite another matter. Darwin by his genius, his patient and skilful observation, deep thought, and dispassionate judgment, seemed triumphant in his explanation of the Origin of Species; Darwinism, to use a convenient term, had won the battle, and many of its followers thought that all that was necessary was to chant a pæan of victory, reckon up the spoils, and settle the boundaries of the conquered territory. Darwin, his enthusiastic followers said, had gathered the harvest, and only the stubble remained to be gleaned by the humble biological goose.

Darwinism, however, has not been satisfactorily demonstrated as a correct mechanism of Evolution, and we must therefore consider what it actually involves,[4] and try to understand where its weak points lie.

The Darwin-Wallace theory involves—(1) *A power of variation in the individual;* (2) *an inheritance of variation;* (3) *an elimina-*

tion of the less fit variations and a preservation of the fit ones by the struggle for existence—Natural Selection.

1. *A power of variation in the individual.*—This is a fact, but Darwinism did not distinguish where this power lay. We shall see presently how far Weismann threw light on this point. The power of variation probably lies[a] in the propagative part of the plant or animal, in their gametes and not in the individual plant or animal—its soma or body—apart from the former. (*See*, however, p. 38.)

2. *The inheritance of these.*—If the factors determining variation lie in the propagative part, they may be transmitted sooner or later in the subsequent generations. A variation in the soma or body of a mere individual, arising from environment, or artificially produced, cannot be transmitted, *i.e.*, an artificial alteration or natural variation in the soma of an individual is not transmitted to

[a] As we shall see afterwards, it is the union of the gametes (*i.e.* ovum or egg, and spermatozoon) that forms the zygote (fertilized ovum) which develops into the adult.

the progeny unless this variation has affected the propagative part and placed in it what would determine the future occurrence of a similar variation. That this is possible has not as yet been shown.[5] There is no accurate or approximately accurate fact in support of the theory of transmission to the offspring of a mutilation suffered by the parent; their great rarity, if we concede a few instances, shows that they are outside the factors producing variation. The operation of circumcision, practised as a religious ceremony probably from the remote age when the generative power was worshipped far back in the rude beginnings of man, has never produced a race of children born congenitally so mutilated. This strongly favours the view that the transmission of acquired peculiarities or traits is not within the power of the soma of the organism. How Darwin attempted to get over this difficulty and failed, in his theory of Pangenesis, we shall presently see.

3. *The third factor, the struggle for existence* (*Natural Selection*), is of the highest

importance. By it, unfit varieties are eliminated, and the fit ones preserved.

Darwinians have, therefore, not yet demonstrated the validity of their first two factors.

The next great advance in the mechanism of Heredity was made by Weismann, and Weismannism, a great theory, was for long, and still is, a magnificent attempt to explain inheritance. Weismann insisted that the power of variation lay in the primitive germ-cells[a] of the sexual glands, denied the transmission of acquired peculiarities, and justified this denial conclusively. He failed, however, to explain how the individual varying characters comported themselves in transmission; he succeeded in the strategy and failed as it were in the tactics of transmission, but he opened up a new path. Unfortunately he met with obstacles which he might have surmounted had he appreciated Mendel's contemporary work. This, along with all the scientific men of his time, he failed to do,

[a] The germ-plasma is the special protoplasm in the gametes and zygote. Many botanists speak of this as the idioplasm, and consider it diffused through the body.

and Weismann's system must remain as a great but unfinished contribution to biological thought.

To discuss this fully we must frankly consider a few questions involved in this question of reproduction, and this can be done simply and modestly from a scientific point of view.

If we consider the case of two animals lower in the scale than man, a fish, for example, like the salmon, we find them "male and female"—sex has differentiated. To reproduce its kind, each of these has a special internal gland which may be termed the sexual gland, and contains, in the case of the female, a huge congeries of eggs or female gametes, the roe; in the male, a great mass of sperm cells or male gametes, the milt. By a duct or tube these can be conveyed outside the body, emerging by a pore into the water as spawn. Each of the elements in the milt and roe may be called a "gamete," and so we have a male gamete and a female gamete. These, at the spawning time, meet in the water and unite

to form the fertilized ovum or "zygote," either a male zygote or a female zygote; from this the fish is developed, male or female, and, in the main, like its progenitors and their ancestors;[a] that is, the gametes and the zygote they form are the carriers of heredity. Instead of speaking of them as carriers of heredity, we might say they contain the "determiners of heredity," or, to use Weismann's convenient term, the "determinants."[6] Thus we speak of the zygote and the gametes from which it is formed, as carrying the determinants of the heredity of the fish developing from the zygote, and the developed fish thus bear a close resemblance to their progenitors—like breeds like.

How does like beget like? As nature always does in her processes, in a very simple way, when viewed broadly. The popular saying is that the child is a "chip of the old block," and like much folk-lore it

[a] Recognizable differences in progeny, minute or marked, may be termed variations.

contains truth, and it is up-to-date with modern science if we say that the child grows from the product of two minute cells of the maternal and paternal sexual glands.

The individual develops from the zygote, but at the very first the zygote forms two primary divisions—one gives rise to the body or "soma" of the future individual, the other is the "primitive germ-cell mass" or propagative part, from which the gametes ultimately arise. This "primitive germ-cell mass" is thus really a part of the zygote, and its ultimate fate is probably as follows. It develops into a number of primitive germ-cells, each still a zygote, and then while the body or somatic part of the individual is developing, these travel into the individual to form with other tissue its sexual gland, and there ultimately become embedded in its substance.[7] They do not, however, remain unaltered primitive germ-cells, but undergo variation changes while in the sexual gland (*vide* Chapter V.), and lose certain determinants, as well as their power of developing into an individual, when they as

acting gametes unite to form a zygote. The gametes are thus reduced primitive germ-cells, *i.e.* not complete in their heredity determinants, and in themselves have no power of developing into an individual, although some biologists assert they can make them do so by immersion in certain simple salt solutions. This, however, is as yet lacking accurate proof.[8] As the male and female gametes are thus "reduced" primitive germ-cells, *i.e.* have lost some of their determinants, and are derived from the early zygote, they have in them a definite but incomplete number of the determinants of heredity. Each fish at spawning-time passes enormous numbers of gametes into the water, and by the union of a male gamete and female gamete, practically a crossing experiment, as in peas (*vide* Chapter II.), we get a zygote with the full number of determinants necessary for a zygote, which then repeats the early history I have given. This matter may be put simply as follows. The zygote resolves itself into an infinity of primitive germ-cells, each a zygote. One of these forms the individual, the rest pass into

this individual while it is developing as such, and by throwing off certain determinants become gametes and lose their power of developing alone into an individual. They are ultimately placed in the sexual gland of each sex. A zygote can only be formed by the union of gametes, but an unreduced part of a zygote, *i.e.* a primitive germ-cell, is also a zygote.

We know that the simplest organism known, the Amœba—a mere speck of protoplasm—reproduces its kind by a bud. This is practically its own equivalent. In higher organisms it is the zygote that buds and produces the primitive germ-cell mass; it then forms its primitive germ-cells, which follow the course already indicated.[9]

This gives us the anatomical basis for Heredity. The organism reproduces its equivalent in the main, because the reproducers, i.e. *the gametes, are a part of the reproduced in its zygotic stage, and each contains a certain number of the determinants of the plant or animal possessing it.* We must now, however, consider the matter in further detail.

The basis of the body structure is the "cell," and when the microscopist examines the tissues of the body it resolves itself mainly into a question of the investigation of cell structure. The same is the case in reproduction. Each gamete is part of a cell,[10] and the zygote is also at first a cell. This question and the essence of reproduction can be best studied in some of the lowest organisms, and one of these has helped to reveal some of Nature's secrets in a very remarkable way.

The traveller on the southern outskirts of Edinburgh, as he toils up Liberton Brae, can note, as he pauses in his ascent, that to his right lies Blackford Hill crowned by the Astronomical Observatory, while up the hill in front of him there may crawl a cart with a dead horse, its hoofs and hairy fetlocks projecting beyond, evidently to the last putting its best foot foremost. Let us hope it was not "killed by blows and hard abuse": at any rate, it has lived an honest life of hard work, and even its remains are to be made into many useful chemical products so com-

pletely that the manufacturer can proudly boast that nothing has been lost to commerce but the "neigh."[a] The presence of the Observatory may set our pedestrian thinking of the famous American observatories high up in their clear dustless atmosphere, where the observers of Mars[11] are watching the death of a world as it were by desiccation, and the gallant fight of the Martians to postpone this. If our traveller is a biologist, the horse will recall to him *Ascaris megalocephala*, the round-worm of its intestine, in which the microscopist can find its gametes and zygotes, and by skilful sectioning and staining get a marvellous peep into the beginnings of a new life, and give us a starting-point to study the beginning of a new organism.

Thus, in a quiet afternoon walk, can one ponder over the beginning and end of life.

Boveri has shown that in the zygote of this animal we get at first a division into two parts,—one the propagative part, the other the

[a] A more fitting end than to be tortured in the Inferno of the Hamburg voyage. An end should be put to the greed of those who care nothing what animals may suffer so long as they themselves can make what they call "gain."

somatic. Balbiani and many others have put the matter clearly and graphically.[12]

A living somatic or ordinary cell is a minute speck of protoplasm with a differentiated part in it, the nucleus, staining more deeply to the aniline dyes, so much used now, than the rest of the cell. By the use of such there can be revealed, in the protoplasmic nucleus, deeply stained rods—the chromosomes—in which, according to the best of our knowledge, the determinants of Heredity lie—a useful theory we owe to Weismann.

When a body-cell, such as a red blood corpuscle, divides so as to produce another, the process is as follows: These chromosomes are first in a "coil," then perhaps, under the guidance of another more minute structure known as the "centrosome," they form horse-shoe loops, split transversely and longitudinally, and then the cell has divided into two. It follows from what has been said that each new somatic cell contains the same number of chromosomes as the one from which it originated, and this holds good of all somatic or body cells (Fig. 1).

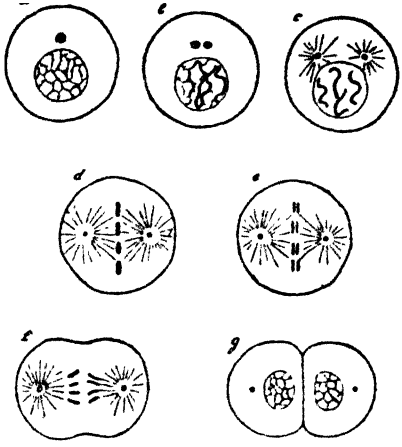


Fig. 1.—DIAGRAM OF CELL-DIVISION (after Boveri).—This diagrammatized figure from Boveri shows the whole cell greatly magnified as a section of a sphere, and the nucleus as the smaller sphere, with chromosomes inside the centrosphere, the directing power in cell division, above.

(*a*) In the nucleus the "chromosomes" are in the coil stage, and it is here that an actual interchange of the determinants may be taking place.

(*b*) Shows the centrosphere divided and the chromosomes forming loops.

(*c*) Here the chromosomes have resolved into four sinuous portions.

(*d*) The chromosomes are four in number, lie between the centrospheres, and the whole arrangement is like a magnetic field. The significance of this is not yet known.

(*e*) The chromosomes are now eight in number.

(*f*) The whole cell is slightly constricted, and each division contains four chromosomes.

(*g*) The nucleus has its chromosomes in each new cell as before, and in the coil condition.

Thus when a somatic or body-cell divides, the chromosomes are not reduced, but remain the same in number.

It is otherwise with the gamete. Each gamete, derived from a primitive germ-cell, contains only half the chromosomes of a body-cell or of a zygote. The number of chromosomes in each of the cells is the same for each species. Thus man has thirty-two; *Ascaris megalocephala*, two or four; the trout, twenty-four. The advantage of the ascaris for investigation is that its cells contain only two or four chromosomes (according to the species), and are thus easily counted in all their divisions. It may be mentioned in passing that the cancer cell has only half the number of chromosomes of a body-cell,[13] *i.e.* resembles a gamete in this respect, a fact the significance of which has not yet been cleared up.

It has also been shown in certain insects that the male gametes and female gametes are each two in number, and that one of the male gametes has an extra "chromosome." This extra chromosome may contain the framework sex-determinants if we regard gametes as sex and non-sex gametes, but as yet the significance has not been settled.

Each gamete is thus incomplete in its determinants of heredity, but the union of such gives a completed heredity to the individual and his subsequent descendants. How this may be studied will be explained when Mendelism is considered. Weismann's deduction from all this as to heredity was that as each gamete—the male one and the female one—contained half the number of the chromosomes of the zygote, the zygote after its first equivalent division contained one-half maternal determinants and one-half paternal. The fallacy in this is, that in the "coil-stage" and afterwards, there may have been a re-distribution of maternal and paternal determinants prior to the equal division, and this would therefore mean that the equal division of chromosomes did not give equal division into maternal and paternal determinants. Thus before the gametes unite in fertilization each contains an incomplete number of chromosomes (one-half of those of the body-cells), paternal or maternal, in its nucleus, but, when they thus blend, the full number is made up. The chromosomes in

the zygote form, as has been already noted, a one continuous coil at first, and then one of their divisions is an equal one. It is evident, then, that what is quantitatively equivalent need not be qualitatively so, and Weismann's statement is tantamount to saying that a bar of gold and one of silver are qualitatively equal because they are quantitatively so.

We have seen that Weismann's theory makes the germ-plasma of the zygote causal in the formation of the individual, and no variation can appear in the individual which is not primarily in the determinants of the zygote. Darwin in his Pangenesis theory supposed that when an alteration in the individual from environment or injury occurred, minute particles were sent from the altered organ or tissue to the "gametes," and thus the variation was transmitted by this secondary process. There is no proof of this theory, and it has been abandoned, but it is not unworthy of its great author, and is the simplest of all such theories.

While Darwinism and Weismannism (not Evolution, be it noted) were in a condition of

"stale-mate," after many successful moves, the problem of the mechanism of the distribution of hereditary qualities in some of its aspects was being worked out by a then unknown observer of supreme intellect, Johann Gregor Mendel (1822–84), Prälat of Brünn in Silesia, in the quiet garden of the abbacy there, and it is his long-neglected but epoch-making work we must next consider. How variations are originated and transmitted must be left for a subsequent chapter (Chapter V.).

II

Mendelism

"Those who survey the work done in this department (artificial fertilization of ornamental plants) will arrive at the conviction that among all the numerous experiments made, not one has been carried out to such an extent and in such a way as to make it possible to determine the number of different forms under which the offspring of hybrids appear, or to arrange these forms with certainty according to their separate generations, or definitely to ascertain their statistical relations" (Bateson, *Mendel's Principles of Heredity*, p. 318, translation of Mendel's original paper).

"Henceforth in this paper those characters which are transmitted entire, or almost unchanged in the hybridization, and therefore in themselves constitute the characters of the hybrid, are termed the dominant, and those which become latent in the process, the recessive" (*op. cit.* p. 324).

"In each of these experiments a certain number of the plants came constant with the dominant character. . . . The average ratio of 2 : 1 appears . . . as fixed with certainty" (*op. cit.* p. 330).

"The ratio of 3 : 1, in accordance with which the distribution of the dominant and recessive characters result in the first generation, resolves itself therefore in all experiments into the ratio of 2 : 1 : 1, if the dominant character be differentiated according to its significance as a hybrid character or as a parental one" (*op. cit.* p. 330).

"The law of combination of different characters, which governs the development of the hybrids, finds therefore its foundation and explanation in the principle enunciated, that the hybrids produce egg-cells and pollen-cells which in equal numbers represent all constant forms which result from the combinations of the characters brought together in fertilization" (*op. cit.* p. 346).

II

Mendelism

WE have just seen that Darwinism gave a mechanism of Evolution of great value, not only from the light it threw on the question itself, but also from the stimulus and guidance it gave to investigation. Research could now be made on a satisfactory working theory of Evolution.

Darwin, however, failed to prove where variation arose and that acquired characteristics were transmitted, and while Weismann showed that in order to be transmitted their determinants must be in the chromosomes of the gametes, in the germ-plasma, he was unable to indicate how this transmission took place so as to square with certain ratio facts in heredity. His deduction that equal division of the chromosomes in the formation of the gametes meant an equal division of maternal and paternal characters, was not

borne out by Mendelian experiment or investigation, and after this conclusion Weismannism fails to solve the question of the mechanism of the ratio-transmission of "characters" in the various generations of plant or animal history.

It is here that the experiments of a man of supreme intellect as an investigator come in, and it is not too much to say that Mendel's researches on variation in plants and on the distribution of the contrasted characters in the crossed plants is the greatest single contribution ever made to Evolution. It is his work [14] we must therefore now consider; but before doing so, we must briefly take up some preliminary matter.

After it had been shown by Sir Thomas Millington and Grew (1676) that the anthers in a flower were male sexual organs, the possibility of artificial cross-fertilization was established, *i.e.*, the pollen of one variety or species of plant could be dusted on the stigma of another, and a positive and variation-fertilization result obtained.

Thus, from 1761 to 1849, Kölreuter

(1761–66), Knight (1799), and Gaertner (1837–49) made numerous artificial cross-fertilizations and established important facts, but no definite conclusions or law. The subject attracted Darwin's attention too, and in 1862 Naudin made a very near approach to a solution. The criticism of almost all these observations, with the exception of Naudin's, is, however, that they were not complete enough, *i.e.*, not pushed through the succeeding generation of plants to a finish; and that the question of the apparent advantages of cross-fertilization obscured the accurate record and tabulation of results.

It is here that Mendel's work was opportune. A man trained in physics and biological science, with a genius for solving such a question by accurately devised experiments carried on until a definite solution was obtained, he viewed the whole problem as one to be determined, not by a limited number of experiments with a necessarily brief note of results, but one to be planned and carried out, for years if necessary, as any accurate experimental and statistical investigation

should be. He therefore determined to experiment on plants, to select certain contrasted characters in them for observation, and by means of cross-fertilization at first, and self-fertilization afterwards, to follow up in the subsequent generations the behaviour of those contrasted characters selected. He tabulated his results as he proceeded so as to obtain a complete view of all that happened. In this way he hoped to ascertain if any law were followed in the transmission of such recognizable characters. What he did in his eight years' experimental work seems to us now reasonable and sensible; but the more one thinks over it the more one sees the genius of the man: it is the eagle's swoop to the goal, simple and easy, but not to be attained by the flutterings of ordinary mortals.

Mendel took the edible pea (*Pisum sativum*) in its many varieties for his experimental work. This pea has many advantages for experiment. It is hermaphrodite, self-fertilizing, little exposed to insect cross-fertilization, and artificial cross-fertilization can be easily practised.[15]

Mendel selected seven varieties of this pea, each with usually one contrasted character, the remaining characters being common to the plants chosen, and he experimented in this way on seven pairs of contrasted characters. These were as follows: (1) Shape of ripe seed, round, or angular and wrinkled; (2) colour of cotyledon, yellow or green; (3) colour of seed-skin, grey, or grey-brown, or white; (4) shape of pod, inflated or constricted between seeds; (5) colour of unripe pod, whether a shade of green or bright yellow; (6) inflorescence, flowers axial (*i.e.* along the axis) or, at the end, terminal; (7) length of plant, tall or dwarf.

Mendel's results in each of the cross-fertilizations with the above seven pairs of contrasted characters or allelomorphs were practically the same, and it will therefore be sufficient to consider one of them.

The experiments made by crossing a tall (6 to 7 foot) pea and a dwarf variety (1 to 1½ foot) are very striking, and this is the one we select for illustration. In such an experiment the pollen of either parent plant is, with suit-

able precautions, dusted on the stigma of the other selected parent, the cross-fertilized parent being then protected from any accidental fertilization from insects, by being covered with a muslin or paper bag for a few days.

The two plants selected are termed P, or Parent; their first generation F^1, and the subsequent generations, F^2, F^3—F^n.

The results in F^1 are very striking. There are no offspring plants of a size intermediate between tall and dwarf, but all are tall and, if anything, a little taller. *The first result of a cross between a* 1½ *foot pea and a* 6 *to* 7 *foot pea, is a generation of pea-plants,* F^1, *all* 6 *to* 7 *feet high.* These are described as Impure Talls, as we shall see more clearly presently.

This result had been previously obtained by others, but the experiments had not been pushed in subsequent generations to a definite statistical finish relative to the selected points, and it was held by Darwin and others to show merely the advantage of cross-fertilization as opposed to continued self-fertilization. Any subsequent fertilization gave what seemed to be discordant results.

Mendel now allowed the peas of F^1 to self-fertilize (*i.e.* they were left undisturbed for the pollen to dust the adjacent stigma), and noted the results in F^2. These gave talls (somatic talls) and dwarfs, 3 : 1. The dwarfs, self-fertilized, now bred true, *i.e.*, only dwarf plants were obtained, however many generations were bred. The somatic talls gave, on self-fertilization, one-third which bred true to tallness, and two-thirds which as impure talls gave somatic talls, and also dwarfs breeding true again in the ratio 3 : 1, as in F^2. All this can be arranged in a diagrammatic form as follows :—

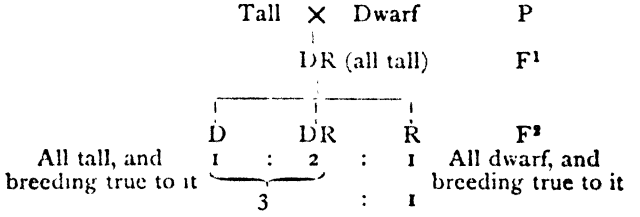


Fig. 2.—Diagrammatized Mendelian Scheme.

D = Dominant, the tallness; R = Recessive, the dwarfness; and DR = impure dominant, *i.e.*, a plant which although tall produced impure talls and dwarfs, 3 : 1. The tall character Mendel termed Dominant; the dwarf, Recessive. Pure talls and pure dwarfs give only talls and dwarfs respectively. × = crossed by or fertilized by.

In F^2, D : DR : R as 1 : 2 : 1, the Mendelian ratio apparently *in the plants* (*vide*, however, p. 38).

There are really two diagrams of Mendel's results, one actual, Fig. 3, and the other, diagrammatized, Fig. 2.

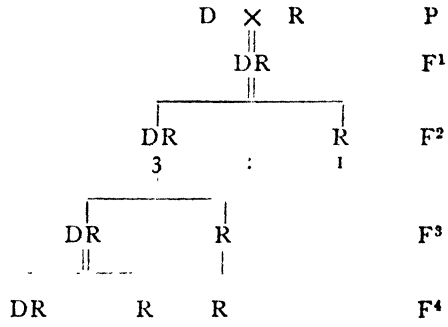


Fig. 3.—ACTUAL MENDELIAN SCHEME.

The student's difficulty is with the DR plants. They are really made up of Dominants breeding true to the dominant quality, and Impure Dominants (DR), which give again impure dominants and recessives. Fig. 2 makes it clearer by giving in F^2 the pure dominants transferred from F^3. This, however, leads to a fallacy, namely, that the Mendelian ratio 1 : 2 : 1 seems to come out as the result of combination of the gametes, *i.e.*, pollen-grains and egg-cells. As we shall see, both pure and impure talls are the same

in their somatic part, and the Mendelian ratio does not come out in the somatic part of the plants at all *in one generation*, but elsewhere. Thus in Fig. 2, in F^2 we have transferred a result *quâ* the plants which only comes out in F^3. As the gametes' influence begins and ends in a generation, their combination cannot produce the ratio 1 : 2 : 1 in the plants of one generation.

We have now to take up more fully the definition and explanation of these striking results.

Mendel described each of the contrasted and selected qualities tested in his cross-fertilization as unit-characters; common unit-characters make up the rest of the plants. Thus tallness and dwarfness in the plant are unit-characters; greenness and yellowness in the peas the same, and so on. He showed that these contrasted qualities did not blend in their consecutive generations, but sifted out unaltered in definite ratios. The unit-characters are thus not blendable but autonomous, and this is of the highest importance in heredity. The

dwarfness does not modify the tallness, nor the tallness the dwarfness, but each unit-character ultimately sifts out in a definite ratio. Mendel described these unit-characters as Dominant and Recessive, and these convenient terms have been generally accepted; but their significance has not yet been defined, and they are somewhat misleading. They must not be interpreted literally, and the meaning applied to them in this chapter will be explained presently.

The ratios in which the selected and contrasted unit-characters (sometimes termed allelomorphs) come out are striking, and the question arises, How does this happen? Mendel in his theory of Gametic Segregation [a] gave a remarkable solution, universally accepted and apparently conclusive. This must now be explained and considered, as it is probably erroneous, and is leading

[a] This means that the contrasted and therefore recognizable unit-characters are pure in the gametes. If, for instance, we take tallness and dwarfness and some other contrasted unit-character, such as roundness and angularity in the peas, all in the same plant, it is supposed that each of these unit-characters is pure in a gamete.

Mendelism to a stale-mate,—*i.e.*, when the theory of Gametic Segregation is applied to explain certain results in Heredity where Mendelism is at work, the explanation fails fully to clear up the process.

In the case of the tall-dwarf crossing, Mendel held that the unit-character of tallness was present pure in the gametes of the tall plants, the unit-character dwarfness of the dwarf plant pure in the dwarf gametes. When these gametes met in fertilization, the chances of union being equal, we get by the law of probability the ratio of 1 : 2 : 1. This may be put simply as follows: If A represents the dominant character, and *a* the recessive, then $(A+a)(A+a)$ by simple algebraic multiplication gives $A^2+2Aa+a^2$.

Neglecting the squares we get

D	:	DR	:	R	
Pure tall	:	Impure tall	:	Pure dwarf	
A	+	2A*a*	+	*a*	
1	:	2	:	1	Mendelian ratio
		3	:	1	Somatic dominant and dwarf ratio

Mendel described the tall character as

dominant, D; the dwarf character as recessive, R, owing to its not being expressed in the plant of F^1, and we may thus use the general expression as to ratios as follows: D being dominant, R recessive, and DR impure dominant,[a] then

D	:	DR	:	R
1	:	2	:	1

Thus the selected unit-characters not only do not blend but separate out in the plants of the subsequent generations ($F^2 - F^n$) in the ratio of 1 : 2 : 1, the Mendelian ratio as we may term it.

This may be summed up as follows: Mendel established that contrasted unit-characters were dominant or recessive, non-blendable, and in the subsequent generations after cross-fertilization sifted out unchanged in definite ratios. Mendelians, therefore, accept Dominance and Recessiveness in unit-characters, explain the sifting out of unit-characters in the Mendelian ratio by the theory of Gametic Segregation (purity of the

[a] Because it does not breed true, but gives DR : R as 3 : 1.

gametes to the contrasted characters) and combination according to the law of chance, and term the fact of sifting out, the Law of Segregation. They also tacitly assume that the changes are to be noted *only in the soma of the plant*, and this is most important.

There are, however, difficulties under this theory :—

1. Why, if this explanation be true, do we get all the plants of the F^1 tall-dwarf crossing, tall, and not talls and dwarfs in the 1 : 2 : 1 ratio?

2. The recessive quality reappears in F^2. Is it not, then, equal to the dominant? Clearly, it is only temporarily recessive.

3. How is the recessive element expressed in F^1? It has not disappeared, as it reappears in F^2 unaltered. It is not expressed in the "soma" of the plant: Where is it?

The error of present Mendelian explanation lies (1) in a misinterpretation of the

ordinary Mendelian scheme (Fig. 2), (2) in stating the Mendelian ratio in relation to the soma of the plant only, and in (3) the non-acceptance of certain facts *quâ* reproduction as to the constitution of a plant or animal. This must be now gone into.

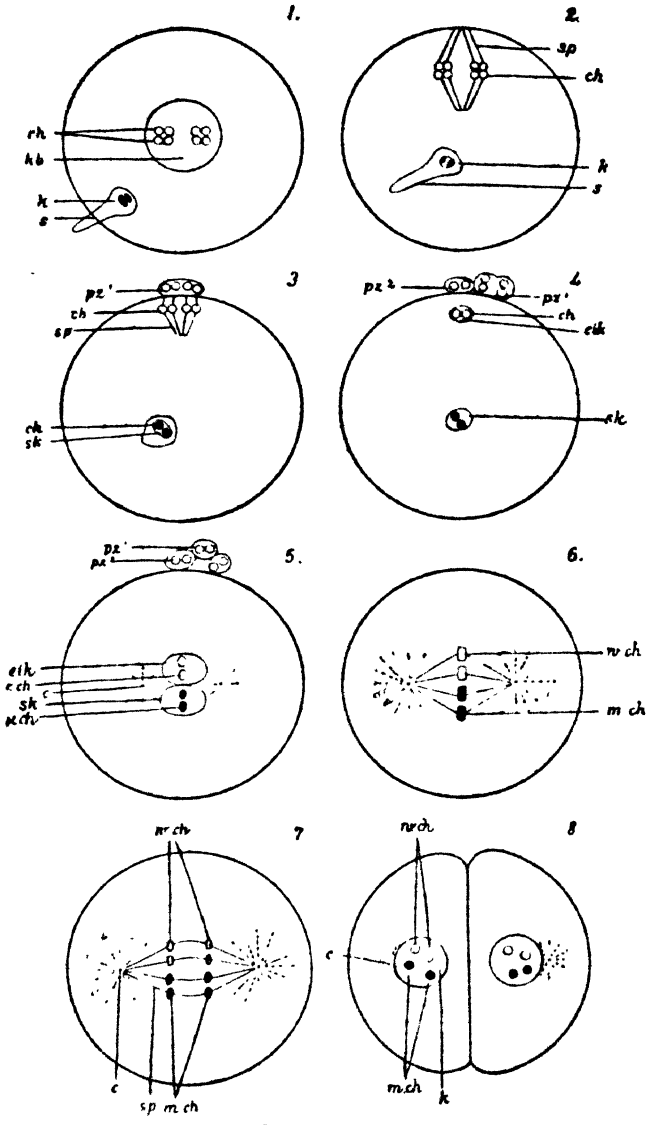
An animal may be considered as made up of an adult individual part or "soma" and a propagative part. The first is the adult or evident animal, the result of the fertilization; the second is the part in, but not of, the "soma" or body of the individual, and is set apart for future reproduction, *i.e.*, contains the gametes.

We have already seen that in the zygote of an animal, in its very earliest stages, a part is set aside from which the primitive germ-cells arise, and that these, travelling through the developing organism reach its sexual glands, being then termed primitive germ-cells, and by losing certain chromosomes on fertilization become gametes. A gamete thus does not contain the complete outfit of determinants necessary to form an adult and its progeny, but the union of gametes does

make up this complement in the zygote, and then the adult develops.

The primitive germ-cells giving ultimately the gametes are directly derived from the zygote and pass into the "soma." They are not influenced by the "soma," but hand on the propagative part unchanged, except so far as malnutrition, alcoholism, and other chemical poisons may have an evil effect. Each individual is thus the trustee merely of its propagative part, and the degenerations of the "soma" do not affect the propagative part.

When the zygote so divides into a propagative and somatic part, the somatic portion contains sufficient determinants—what Weismann termed an "id" *minus* sexual framework determinants, to develop an individual; but each germ-cell also contains an "id," is an unreduced part of the zygote, and thus each sexual gland contains thousands of ids, and each male or female gamete a fraction of an "id," made up to a whole or zygote by combining with another part of an "id" in another gamete, *i.e.*, by fertilization. But the determinants in the


1.
rh
hb
k
s
2.
sp
ch
k
s
3
pz'
ch
sp
ch
sk
4
pz 2
pz'
ch
eik
sk
5.
pz'
pz 2
eik
ech
c
sk
mch
6.
nr ch
m ch
nr ch
7
c
sp
m ch
nr ch
8
c
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k

Fig. 4.

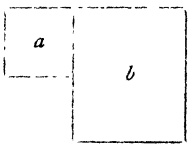
somatic "id" may vary from those in the ids of the combined gametes, and thus a highly important fact has to be noted, namely, that an individual contains in the gametes of its sexual gland determinants of qualities which are not present in its "soma," *i.e.*, it has determinants secluded or "interned" in the gametes of its sexual gland whose results appear in its progeny, although not actually in the parent "soma."

In plants there is probably the same arrangement, but the details have not been so well worked out as in animals. The botanist has usually regarded a somatic cell as having some generative propagative powers too.

Description of Fig. 4.

Fig. 4.—FORMATION OF ZYGOTES (from Boveri and Hertwig). Shows in 1, the male gamete (*s*), with two chromosomes (*k*) penetrating the female gamete, which has two groups of chromosomes (*ch*), each forming a tetrad in the nucleus (*kb*). In 2, the gametes are approaching. In 3, one group of tetrads has been thrown off (pc^1). In 4, a dyad group has also been expelled. In 5, we see the reduced nuclei of the gametes, each with half the number of chromosomes approaching, and the directing centrosomes are on each side (*c*). In 6, we see the four chromosomes made up, and two are assumed to be maternal and two paternal. In 7, a longitudinal division of the chromosomes takes place. And thus in 8, the divided cell, *i.e.* each half of the zygote, has the full number of chromosomes.

Important results follow from this view, and they may now be applied to Mendel's pea crossings, its application to Man being left for discussion in the chapter on Heredity.

It must now be noted that the Mendelian scheme should be applied to the zygotes giving rise to the plants and not to the plants themselves *quâ* their soma. We must regard the zygote as made up of a propagative and somatic part, the former giving rise to the pollen grains and egg-cells, which are thus handed on, and alone determine the nature of the plant, and the somatic part which forms the "soma" of the plant lasting for a generation only. The outline figure expresses this. Thus 

represents the zygote, the small square the propagative part, *a*; the large one, the somatic part, *b*. In each of them determinants lie: in the one, *a*, for the race; in the other, *b*, for the individual. The Mendelian scheme may now be drawn up as follows:—

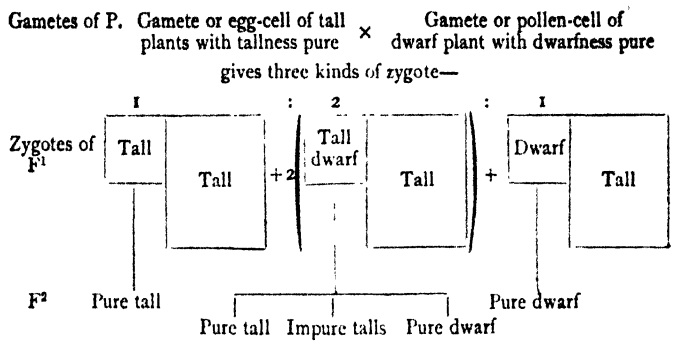
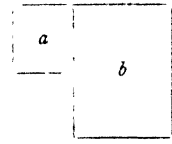


Fig. 5.—AMENDED MENDELIAN SCHEME.

In this amended Mendelian scheme, P gives gametes to be crossed, *i.e.* egg-cells and pollen grains (or *vice versa*) with tallness or dwarfness pure in each gamete:



$a+b$ gives figure of a zygote, with propagative part the small square, a, and somatic part the large square, b; F^1 shows the zygotes on this view, and indicates that the Mendelian ratio 1 : 2 : 1 is *in the determinants of the unit-characters of the propagative part, and not in the somatic part of the zygote.*

In the tall-dwarf crossing (Fig. 5) the zygotes of the tall parent in F^1 have in their propagative part the dwarf and tall determinants in the ratio of 1 : 2 : 1, as we shall see; but in the somatic part, giving rise to the tall plant itself, only the tall determinants. In F^1 we thus get all the plants tall, and as

F^2, arising from F^1, has impure talls and dwarfs, F^1 is said to consist of impure talls, owing to the somatic talls not all breeding true to tallness. The error in this conception is, that it does not state where in the plants of F^1 the impure tallness exists. From what has been said, the F^1 tall plants can contain no dwarf determinants in their soma, but only tall determinants. The dwarf determinants are really secluded along with tall ones in the propagative part of the impure talls, and appear in F^2 plants in a certain ratio. Mendel considered tallness as dominant and dwarfness as recessive, as the latter did not appear in F^1 plants. It appears in F^2, and has an equal right to be called dominant then. The fact is, the terms Dominant and Recessive are striking but misleading, and we may therefore say that *when two plants with contrasted single unit-characters are crossed, then in F^1 in one quarter of the zygotes there is tallness as a determinant, both in the propagative part and in the somatic part; in a half we have tall and dwarf determinants in the propagative, but only tall determin-*

ants in the somatic, part; while in the remaining quarter there are dwarf determinants in the propagative part, and tall ones in the somatic part (Fig. 5). We may therefore accept Mendel's facts as to the transmission of unit-characters unaltered and their sifting out in certain ratios, but the sense in which he used dominance and recession is misleading, and the ratios sifted out are due to changes in the zygote, to interchanges between the somatic and propagative parts of each zygote, giving the 1 : 2 : 1 ratio in the unit-character determinants of the propagative part, and not to gametic combination.

The special points bearing on Human Heredity in Mendel's great work, and that of the continuity of the germ-cells, seem to me to be—

1. That unit-characters are autonomous, not blendable.

2. That the determinants of a character may be secluded or "interned" for a generation, or even for very many

generations, in the propagative part, and their appearance later (so-called recession, or when long postponed, atavism), although not expressed in the "soma" of the parents, thus explained.

3. The explanation of this "seclusion" depends on the view I have advocated as to a plant or animal being considered as made up of a propagative and a somatic part, the former being outside the influence of the latter. *The Mendelian ratio happens from a rearrangement of the unit-character determinants between the propagative part and the somatic part of the zygote, not by combination of the gametes when forming the zygote, and is expressed in the propagative part of one generation. As a result of this we get the crossed plants segregating out their qualities in their progeny in two successive generations*, but this is secondary to the ratio in the propagative part.

The theories by which Mendel's facts are explained seem therefore to require revision, and certain assumptions made are really due to a misinterpretation of the ordinary scheme (Fig. 2) displaying the facts of transmission in a crossing-pea experiment.

The summary of my views is therefore as follows :—

1. The appearance of the contrasted unit-characters is described solely in relation to the "plant." Thus in Fig. 2 it is assumed that in F^2 the Mendelian ratio of 1 : 2 : 1 comes out in the plants. It does not. What really occurs is a ratio in the plants of impure dominants to recessives, 3 : 1 (Fig. 3). The result of the appearance of pure dominants appearing in F^3 is transferred to F^2, and thus we get the ratio 1 : 2 : 1 plotted out in Fig. 2.

2. Dominance and Recession in a unit-character are spoken of, especially in regard to Recession, as if they were special qualities, and that when one

spoke of a "recessive" element it had some special power. Dominance and Recession mean a difference in the time of the transmission, a dominant unit-character is expressed in the soma of the plants in F^1, while the recessive element is delayed in appearing in the plants by a generation.

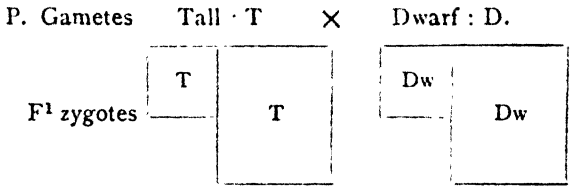
3. While in the tall-dwarf crossing their single unit-characters are pure in the gametes, it does not follow that when we have multiple pairs of unit-characters in the crossing plants *they need to be pure in special gametes.*

4. The combinations giving the Mendelian ratio happen in the zygote, and therefore, however the unit-characters are distributed in the gametes, they assume the 1 : 2 : 1 ratio in the zygote. This is of the greatest importance.

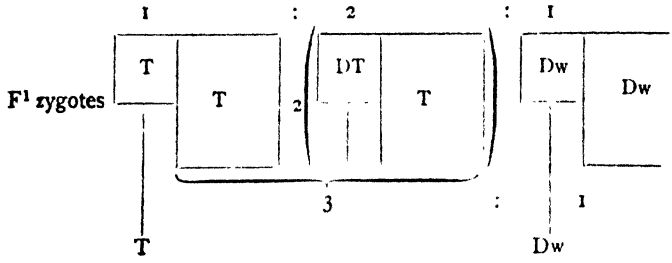
5. Mendel's theory of gametic segregation is wrong, and, as the combination of the gametes must end in a generation, cannot occur.

6. I regard the zygotes in each crossing as made up of a propagative and a somatic part. It is between these that the unit-characters are distributed, and in the propagative part that the Mendelian ratio is obtained.

7. In any scheme of the history of the distribution of the unit-characters from P to F^n we must consider the zygotes, not the soma of the plant, and read as follows :

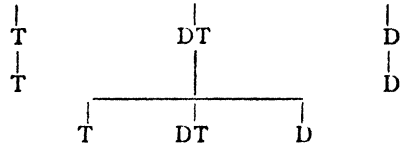


The small attached square represents the propagative cell mass, giving rise to the gametes (pollen grain and egg-cells); the large one, the somatic part, giving rise to the plant. There are three zygotic results when the pollen grains and egg-cells of P meet—



The Mendelian ratio thus appears in the propagative cell mass of the zygotes of F¹: afterwards in the results of the DRs only. The plants in F¹ are therefore pure talls *quâ* their soma. The talls differ, however, in their propagative part.

When self-fertilization of the gametes in F¹ takes place, we get—



and so on.

8. The propagative cell determinants thus determine the Mendelian ratio. They are the important part in the plant's

life history, and it is they that determine its propagative value.

The true reading of the Mendelian scheme is therefore as follows :

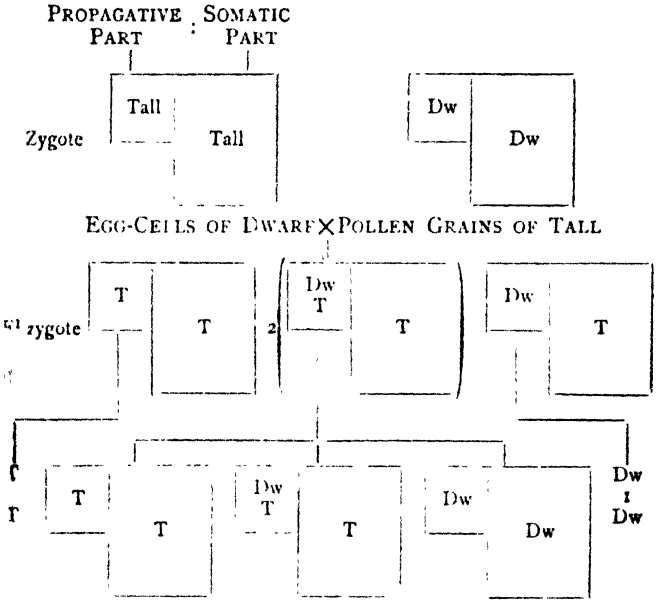


Fig. 6.—AUTHOR'S MODIFIED MENDELIAN SCHEME.

When a pure tall and a pure dwarf cross, we get in F^1 zygotes of three kinds—

(1) In the propagative part and somatic part of one quarter, tallness is pure; (2) in a quarter, dwarfness is pure in the propagative

part and tallness in the somatic part; (3) in a half, tallness and dwarfness are present in the propagative part with only tallness in the somatic. Tallness is therefore pure in the somatic portion of each zygote of F^1. Thus all the resulting plants are tall: the quarter with dwarfness pure in the propagative part necessarily breed true to dwarfness; the quarter with tallness pure in the propagative part, in like manner breed true to tallness; while in the half with both dwarfness and tallness in the propagative part, we necessarily get in F^2 the same result as in F^1, and so on. The dominant character would be better termed the *first character*, as it appears first in the soma of F^1; while the recessive should be considered the *second character*, as its expression in the soma is delayed to F^2.

We see, then, that the soma of the plants is the transient part whose life is merely in a generation; it is the propagative part that lives and transmits, and this is the point in Tennyson's lines—

> "So careful of the type she seems,
> So careless of the single life."

III

Mendel

"This is our master, famous, calm, and dead,

. . . . .

Long he lived nameless:

. . . . .

Leave him--still loftier than the world suspects,
Living and dying."

ROBERT BROWNING,
"The Grammarian's Funeral."

III

Mendel

MENDEL'S important discoveries are enhanced in interest by the events of his career. There is no more remarkable fact in the history of biology than the entire neglect for many years[a] of such outstanding work as that of Mendel. It was not that it was published in inaccessible Transactions, as these were exchanged with the Linnean and Royal Society publications in our own country. Mendel's work never came under Darwin's notice, and Nägeli, a transcendental biologist with whom he corresponded, as we now know from the published letters, failed completely to recognize the importance of Mendel's experiments, evidently mainly engrossed with his own speculations

[a] Mendel published his results in 1865; he died in 1884, and attention was drawn to his work in 1900.

on Idioplasm. How did all this happen? In the first place, the previous workers at cross-fertilization, with the exception of Naudin, had obtained no understandable results. The experiments occupied time and were not made on any continuous plan. The greatest hindrance to their acceptance was, however, the brilliancy of Darwin's work. No one accumulated facts so carefully as Darwin or thought over them more thoroughly. He was no hasty speculator, and indeed his earliest account of his work was really wrung from him by Wallace's Essay, sent to him for consideration. When, however, Darwin did publish his *Origin of Species* the flood-gates of speculation were opened, and the theory of the Struggle for Existence was used as the master-key to unlock all Evolution mysteries by many who had not Darwin's greed for facts, and certainly not his genius. One man, however, kept his head—Mendel, and acted on John Hunter's famous maxim, "Don't think; try": that is, don't speculate, experiment! Who, then, was Mendel?

Johann Gregor Mendel was born on 22nd

July 1822, at Hendzendorf bei Odrau, in Austrian Silesia, and was German by descent. His parents were peasant proprietors, and Johann was evidently a lad of ability, or of "pregnant pairts," as was the old phrase in Scotland. His parents, and especially one of his sisters, at the cost of considerable privation, gave him the education such ability deserved, and one of his teachers at Troppau, an Augustinian, may have influenced him in his decision to become a monk, as he entered the Königskloster in Brünn and was ordained priest in 1847. In 1851 he was sent at the expense of the cloister to Vienna for two years, and there studied Natural and Physical Science. The Roman Catholic Church has always given its promising students the utmost advantages for prosecuting the studies for which they seemed fitted, with results science well knows. Protestant Churches would do well to follow this lead, and we should then be spared the spectacle of their acutest minds, when not occupied with investigation where thought is hampered, wasting their powers on the obscurities of Browning or the

subtleties of Meredith. The Roman Catholic Church is, however, not seen in so favourable a light in its treatment of Mivart, who was excommunicated by Cardinal Vaughan, and in the difficulties as to his interment. Why should the Church war with the dead?

Mendel was a successful teacher, and in 1868 was appointed Prälat at Brünn. His pea-crossing experiments were evidently undertaken to ascertain the mechanism of the transmission of contrasted characters, and he saw that such experiments must be pushed to a finish. It is this, and his clear method of presenting his results, that give them their outstanding value. The plan of research he laid down, and the way he carried it out, are masterly and a model to all workers following in his lines, as so many are doing at present. Brilliant results are being obtained, but Mendel's terminology as to dominance and recession and the theory of gametic segregation have been in my opinion too hastily accepted, and must be reconsidered if real progress is to be made.

After eight years' strenuous work, Mendel

apparently gave up his plant experiments, but he certainly saw farther than any of his contemporaries, as his experiments in bee-fertilization show. In these he was unsuccessful from technical difficulties, which will probably be now overcome. Unfortunately, all record of this work has been lost.

What really made Mendel lay aside his great work was probably not only its apparent failure to influence biologists, but also the bitter resistance he made to the proposals of the Austrian Government as to the taxation of monasteries. Perhaps his disappointment in his scientific work had soured him and led him to undue resentment: here was something more tangible to fight against, than the shadowy indifference of contemporary scientific workers. Posterity would see the latter, he thought, in its true bearings. His recorded saying, "Meine Zeit wird schon kommen," shows this, and has been amply verified.

Mendel died in 1884, unknown and unrecognized in science; but no name, except those of Darwin and Wallace, will shine more brightly in modern biological record. Yet he

had in his lifetime many compensations. His work was of surpassing interest to him, and, if neglected, was not soiled by ignorant or party criticism, and he was spared the useless controversy so many great men have been led into. He had the joy of the solution, if not in his lifetime the credit. His life must have been a happy one in his quiet retreat. I am certain that he smoked, and that he rose early to see how his plants were faring. At times he would think them tardy in their work, but any such idea would be checked by Goethe's line, "Ohne Hast aber ohne Rast," rising to his recollection. The days when the pea results were enumerated would always be red-letter ones to him. His many eager colleagues in the cloister would help him, no doubt—some keen, some sceptical. Probably he would be considered a little "daft" in the matter of his hobby. Barclay's[16] parishioners in St. Andrews thought highly of him, but jokingly described him as "aye skinning puddocks."[a] Whatever the monks in Brünn thought of Mendel, none followed up his work.

[a] *Anglicé*, frogs.

Mendel

We are fortunate to have three portraits of Mendel.[a] One of him is as a young man; another in middle age; and a third, late in his life. The first shows the brightness of youth. The head is of the Napoleonic and Goethe type—that of a man of tenacity and genius. In the second we have the look of apparent success, of activity and precision. In the last, close-cropped, clean-shaven, we still see an impressive countenance, but it is sterner, and the grip of the lips is firmer—evidently the face of a man to whom life had no illusions, and in whom duty was pre-eminent.

One regrets that Mendel's star went out in temporary darkness, and it is to be hoped that scientific thought will take the lesson Mendel's life affords in this respect and profit by it, and that we shall see less of the indifference or actual clubbing that is dealt to the investigator who tries to leave an official beaten track through a sterile land, for the brighter landscape his prophetic eye sees from his new standpoint.

[a] These are given in Bateson's recent work.

IV

Biometry
Mnemism

"To talk about inheritance is much easier than to study it. Of the books and essays which meet us at every turn, few have much basis in research, but among the few are those of Francis Galton."

W. K. Brooks, *The Foundations of Zoology*, p. 153.

IV

Biometry
Mnemism

THE founder of Biometry in Britain is Galton, and Karl Pearson is its prophet. Galton's work has stood the severest of all trials—its study in the light of modern research; and it has come out of it, if not as triumphantly as Newton's and Harvey's, at least most successfully. It is possible to read Mendelism and of the continuity of the germ-plasm, and see a germ of each in Natural Inheritance.

Biometry is not welcomed by all investigators, and Bateson has said of it: "Of the so-called investigations of Heredity, pursued by extensions of Galton's non-analytical method and promoted by Professor Pearson and the English biometrical school, it is now

scarcely necessary to speak. That such work may ultimately contribute to the development of statistical theory cannot be denied, but, as applied to the problem of Heredity, the effect has resulted only in the concealment of that order under which it was ostensibly undertaken to reveal. A preliminary acquaintance with the natural history of Heredity and Variation was sufficient to throw doubt on the foundations of these elaborate researches. To those who may hereafter study this episode in the history of biological science it will appear inexplicable that work so unsound should have been respectfully received by the scientific world" (Bateson, p. 7).[1]

Biometry is not an easy study; it requires careful and prolonged measurements, and the use of higher mathematics by Pearson and his school has put it, in this aspect, beyond the grasp of most observers. If we look at it, however, as a method of investigating certain facts, its value can easily be seen and will certainly increase.

The objection to it was raised by Huxley

with his wonted acuteness. "Mathematics may be compared to a mill of exquisite workmanship, which grinds your stuff to any degree of fineness, but nevertheless what you get out depends on what you put in; and as the grandest mill in the world will not extract wheat flour from peas-cods, so pages of formulæ will not get a definite result out of loose data" (quoted in Karl Pearson's *Eugenics*, p. 17). Pearson answers to this: "I assert that our modern mathematical methods result in perfectly definite results when applied to such data: they measure the deviation, the differentiation of peasemeal from wheat flour: that is to say, they determine quantitatively the exact degree of looseness in the data themselves" (*op. cit.*, p. 17). It is useless, however, to fight in metaphor, and in fact the three controversialists are merely "biting their thumbs at one another" like the rival factions of old in Verona.

Biometry has made most useful contributions to Biology. It enables the biologist to make measurements of evident variations

in plants, fruits, nuts, and other suitable material, and to state what these are on an average. Thus when we measure an array of pea-pods we can plot out the results, get the average length, and the extremes in length ; and from this, state the median (the mid-length), and so on. Whether we measure nuts or men, fruits or pods, or toss coins, the results plotted out find practically the same kind of curve, which "rises rapidly at first, keeps level, and then rises rapidly at the end" (Elderton, p. 13).[a] These individual variations in the size of leaves, pea-pods, percentages of sugar in beetroot, height of men, follow Quetelet's law, and the numbers of the various results when plotted out give a definite curve, which can be predicted.

It would be too technical to consider the questions of Correlation and the Coefficient of Correlation, and this is unnecessary, as we have now excellent works, advanced and elementary, on those questions.

Galton formulated certain laws, which are important—that of filial regression, for in-

[a] *Primer of Statistics*, Lond., A. & C. Black, 1909.

stance; but the most widely known one, Galton's law, setting forth the supposed fractions making up the full heredity in the individual, is of great importance, and has been specially fought over since Mendelism began to exert its sway in Evolution. Galton held that each individual inherited $\frac{1}{4}$ from each of the two parents ($\frac{1}{2}$ in all) and $\frac{1}{16}$ from the four grandparents ($\frac{1}{4}$ in all), $\frac{1}{32}$ from the eight great-grandparents, thus making up the approximate total required. Pearson has modified these fractions, but we need not dwell on this.

We may therefore, using Mendel's term of unit-character, say that, according to Galton, offspring inherit one-half of their unit-characters from the parents, and the most of the other half from the grandparents and great-grandparents.

There are, however, important criticisms on this law :—

1. We cannot limit the inheritance of unit-characters back to the great-grandparents merely. The continuity of the germ-cells shows us that in inheritance

we go back beyond them to far-back ancestors, even to allied species occasionally in certain mammals.

2. The Mendelian ratio of 1 : 2 : 1 in which unit-characters are transmitted in Mendel's plant- and animal-crossings, is not that of Galton's law.

3. Mendelism emphasizes the autonomy of unit-characters in the transmission: the idea implied in Galton's law is that of blending.

4. In the human species the mother seems to have a preponderating influence in transmitting the unit-characters of the boy: the father in that of the girl; thus the immediate fractions are more than the quarter respectively Galton requires.

While, therefore, Galton's law is of importance and of the highest value in its idea of quantitative transmission, the whole question of the amount of the distribution of unit-characters in heredity has yet to be settled. This does not diminish in the least

the credit due to Galton as a pioneer in this special direction.[a]

Biometry has a great future as a method in Evolution. The objection urged as to its not having discovered much as yet is unjust; but, like many aspersions, there is probably some grain of truth in it.

The amount of hard work by biometricians in accumulating measurement-facts and noting minute variations is enormous. We get a good illustration of that in some of the late Francis Welldon's work. This eminent biologist was a most enthusiastic follower of biometric work, and in the sympathetic biography in *Biometrika*, by Karl Pearson, we see how Welldon spent himself, sometimes successfully and sometimes unfortunately, it must be said unsuccessfully, in arduous observations, unremunerative as yet in scientific deduction.

Biometry may thus investigate irrelevant facts, or it may be supplied with loosely observed ones. Some illustrations may be

[a] See remarks on Weismann's Equal Division of the Maternal and Paternal Chromosomes, at p. 20.

given on the first of these statements. Illustrations of the second one will occur to all. Pearson describes one of Welldon's researches as follows:

"In this paper Welldon returns to the problem of whether frontal breadth in crabs is correlated with a selective death-rate, but he now deals with type and not variability. He first approaches the problem from the consideration of whether for this character the crabs in Plymouth Sound are remaining stable, and he shows from measurements made by Sir Herbert Thompson and himself, during the years 1892 to 1896, that the population is unstable. He next seeks a cause for this secular change, and he finds it in the turbid state of the water in Plymouth Sound, due to the continual carriage into it of large amounts of china clay and sewage. Direct experiments were then made on the selective death-rate of crabs kept in water with suspended china clay, and on another occasion in foul water. In all cases the survivors were found to have a smaller frontal breadth relatively to their

carapace length. Confirmatory experiments showed that after the first shock of confinement was passed, this selection did not occur among crabs kept in pure sea-water. A reasonable explanation of this selective action was provided in the character of a crab's breathing apparatus. Thus, after several years of discouragement and much hard labour, Welldon succeeded in demonstrating that Natural Selection was really at work, and further, that it was at work at a very sensible rate. The labour involved was excessive. One "crabbery" consisted of 500 wide-mouthed bottles, each with two syphons for a constant flow of sea-water, and each crab had to be fed daily and its bottle cleaned. During the summer of 1897 Welldon spent the whole of his days at the aquarium, and his wife hardly left him except to fetch the needful chop. The sewage experiment was "horrible, from the great quantity of decaying matter necessary to kill a healthy crab."

The stature measurements made, usually give the relations of fathers and sons. This

is probably not the line of most effective descent, as sons have a higher relation to the mother's side than to the father's. We need, therefore, measurements and data as between maternal grandfather and mother and son. The line of descent is a zigzag one, thus—

Huxley's objection still holds good. With Biometry we can appraise the relations of facts, but not the facts themselves. Biometry is not like the sovereign weighing-machine at the Mint, which not only accurately weighs but rejects the light coin submitted to it. There is, however, an unexpected confirmation of the claims of Biometry in certain embryological facts hitherto considered obscure, which will be discussed in Chapter V.

Mnemism.—The central problem in any mechanism of Evolution — Darwinism or Weismannism—is to explain how variation arises and how it is transmitted. This is why Darwin formulated his Pangenes (*vide* p. 20).

Mnemism

Darwin speaks of the power of variation in the plant or animal, and Weismann placed this power primarily in the germ-plasma. When once a variation arose by the power of initiation in the germ-plasma, it might be perpetuated or might be swamped, according to Fleeming-Jenkin, in the case of single variations. Darwinians who hold that environment produces variations on the soma of the plant or animal, are still struggling to get the supposed somatic variation conveyed to the germ-cells and thus passed on to the progeny.

Mnemism is the latest and most imaginative of the theories whose aim is to connect a somatic variation with the germ-cells, so that the latter have something added to them which makes them causal to their progeny *quâ* this somatic variation.

Richard Semon, the originator of this theory of Mnemism, is a distinguished biologist who has made his mark as a traveller and investigator in Australia. He is therefore no mere laboratory speculator, but one whose views must be carefully

weighed. Mnemism has been specially advocated in this country by Mr. Francis Darwin, who in his Presidential Address to the Biology Section of the British Association, at its Dublin Meeting in 1908, gave a most lucid account of it. It is evident, however, that Mr. Darwin is more fascinated than convinced by Mnemism. Thus he says: "Semon faces the difficulty[a] boldly. When a new character appears in the body of an organism, in response to changing environment, Semon assumes that a new engram is added to the nuclei in the part affected; and that, further, the disturbance tends to spread to all the nuclei of the body (including those of the germ-cells) and to produce in them the same change. In plants the flow must be conceived as travelling by cellular protoplasmic threads, but in animals primarily by nerve-trunks. Thus the reproductive elements must be considered as having in some degree the

[a] The mechanism by which somatic changes in the plant and animal are made causal in the gametes, or the mechanism of the transmission of acquired peculiarities.

nature of nerve-cells; so that, for instance, if we are to believe that an individual habit may be inherited and appear as an instinct, the repetition of the habit will not merely mean changes in the central nervous system, but also corresponding changes in the germ-cells. These will be, according to Semon, excessively faint in comparison to the nerve engrams, and can only be made efficient by prolonged action. Semon lays great stress on the slowness of the process of building up efficient engrams in the nerve-cells" (*Nature*, vol. lxxviii. p. 423).

Semon's engram is the potentiality put into the nucleus of a cell by what produces the variation, and this engram produces a causal one in the germ-cells, as above described. That there is, however, any such mechanism, conveying somatic cell engram influence to germ-cell nucleus, is as hypothetical as any of the suppositions of scholastic philosophy, and is indeed a mere figurative and literary way of stating the problem, not of solving it. The mechanism of the conveyance of somatic alterations to germ-cells

cannot be stated or explained, as there is really no such arrangement for it in the plant or animal organism. It is like the squaring of the circle or the theory of perpetual motion, a problem the evident answer to which follows its enunciation.

Have we, however, any mechanism in the organism for producing and transmitting variation? We have, I believe, and I now go on to indicate, not a solution of the problem, but a probable method of its solution. The problem is—(1) *How do variations arise?* (2) *How are such variations transmitted?*

This, however, must take up another chapter.

V

An Intrinsic Theory of Variation and its Transmission.

Mutation

Every investigator has the defects of his qualities. It is the theorist who has his attention drawn to this most frequently by his more prosaic critics. Yet Linnæus, the great Systematist, made the mistake of his life, and stereotyped Botany for years when he said, "Varietates levissimas non curat Botanicus."

V

An Intrinsic Theory of Variation and its Transmission.

Mutation

THE questions of the origin of Variations and the transmission of Variations are really the essential parts of any mechanism of Evolution, and if we can solve these two problems we shall be appreciably on the road to a more complete understanding of it. In this chapter I wish to sum up, with some necessary repetitions, and to expand, what has been said in the previous pages on this subject, and also to emphasize a theory already indicated, which for convenience may be termed an Intrinsic Theory of Variation and its Transmission.

Darwin, as we saw, accepted the occurrence

of Variation as an axiom. Variations were by him supposed to be innate, or to result also from environment, and innumerable experiments and suggestions have been made by evolutionists in support of this latter view. Of course, the fallacy in all such is that they may be made while some unknown factor is acting and really causing the Variation; hence the discordant results.

One great difficulty Darwin had was to account for the transmission of the variation. He supposed, by his ingenious Pangenesis theory, that the sexual gland was made up as it were of samples from the various tissues of the body; that when an injury was inflicted on the body, or some variation induced by environment arose in the body, gemmules were sent from the altered part to the sexual gland, and thus made it causal to the variation. The theory has been found ineffective and is now abandoned. I have already described Semon's theory of Mnemism and indicated the difficulties one has in accepting it (Chapter IV.).

In considering this question we must

remember that variations are constantly occurring, in the members of the human race, for instance, although in some there is not, and cannot be, any transmission and therefore no heredity. Heredity bulks so largely in the scientific and popular imagination that at present all deformities are being considered in relation to it. In the human race certain deformities, better termed variations, are occasionally found in regard to the fingers, lower limbs, sexual organs, and many other parts of the body. Deformities in the sexual apparatus turn up with a fair amount of frequency, and have done so for ages, and yet from their nature the unfortunate possessors are sterile, and there can therefore be no question of the transmission of such a variation. One therefore must ask, May it not be the case that there is something prior to and immediately after fertilization in the structures concerned in this process that causes and transmits variation? Are the biologists who look about for some mechanism that will make the actual somatic variation or injury causal in the germ-cells not really

on the wrong line of investigation altogether? I believe they are.

In 1846 Quetelet published a very famous book consisting of a series of letters to the reigning Duke of Saxe-Coburg and Gotha, in which he took up the question of the Theory of Probabilities as applied to the moral and political sciences. This work certainly attracted attention, and a well-known critique of it was written in the *Edinburgh Review* of 1850 by the distinguished astronomer, Sir John Herschell. While Quetelet's work has not been completely neglected like Mendel's, yet sufficient credit has not been accorded to him. In England, however, we are fortunate in having a school in Francis Galton, Karl Pearson, and their followers, who have carried on Quetelet's work.

Quetelet showed that if one took anatomical relations, such as the circumference of the chest in the Scottish soldiers, if one took the target at which a thousand shots had been deliberately fired, it would be found that the results, plotted out as to frequency of occur-

rence, all followed the curve of probability. This has been further extended by many

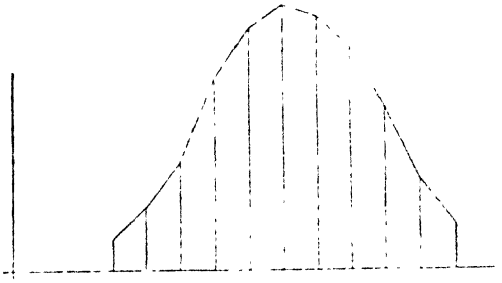


Fig 7.—FREQUENCY POLYGON, showing the distribution of measurements of an "organ" in a sufficient sample of the population (Worthington).

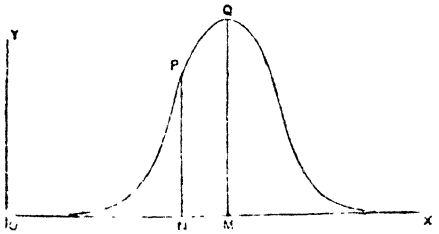


Fig 8.—The same as above, but with a more continuous curve, owing to greater number of observations. QM = ordinate, about which the curve is symmetrical, and is proof that there is no gross error, or that QM is the frequency of the true observation. PN is the frequency of gross error proportionate to NM, and MN is the probable error of the observations (Worthington, *Journ. of Anat. and Physiol.*, vol. xxxv.).

observers in this country and elsewhere, and we now know that this Law of Probability

governs, we may say, all the results of growth, the birth-rate, the incidence of disease, the death-rate, the distribution of boys at some stage of a school-race; and the question arises, Why is this? Why should the developed structures of a man's body, of his functions and all connected with him, follow this curve or some of its modifications?

I have already explained that at the earliest period of the growth of the fertilized ovum (or zygote) a part is set aside, termed the primitive germ-cell mass, to form the primitive germ-cells, which ultimately give rise to the gametes. I have explained that in the very earliest stage of development, before even the embryo is formed, these primitive germ-cells travel through the developing organism and ultimately become embedded in the sexual gland. Now, living cells may increase their number in two ways. There may be an exact division of the cell substance and nucleus, and in this way, as one sees constantly in the cells of developing gristle or cartilage, new cells are formed, each almost the exact replica of its parent. This

process is called Amitosis. There is, however, another way by which cells increase their number, namely, the process known as Mitosis. Here the chromosomes of the nucleus undergo elaborate changes. From a continuous coil they form horse-shoe loops. These split, the chromosomes are divided accurately, and finally each cell is made into two, with the doubled chromosomes accurately divided between them (Fig. 1). It is remarkable that while the germ-cells are travelling to their sex-gland they do not undergo this mitosis at all. (Beard). When, however, they are in the sexual gland this complicated process of mitosis begins, and the primitive germ-cells are increased in this remarkable way. The observer who has done most to give us the details of this process in the female sex-gland, von Winiwarter, believes, like almost all embryologists, that they indicate the transition between what is termed the germ-epithelium covering the sexual gland and the primitive germ-cell. On this point I must give a brief and simple anatomical explana-

tion. The sexual gland (the ovary and testis) is covered with a layer of ordinary epithelium, termed the germ-epithelium. This is continuous with the lining or epithelium of the abdominal cavity, and is a modified thickened form of it. At an early stage in the embryo this special layer proliferates, and in it are found the primitive germ-cells, which I have already described as travelling towards the sex-gland after they had been separated off at the early division of the zygote. The generally received opinion has been that these primitive germ-cells lying in this germ-epithelium are derived from the germ epithelial cells. This theory, although generally accepted, I believe to be absolutely erroneous. The germ epithelial cell is merely a body-cell ; the primitive germ-cell contains unit-characters of Heredity. The question arises, therefore, Why do the primitive germ-cells, when in the developing sexual gland, undergo the complicated changes of mitosis well seen in Fig. 9. The key to this is, I believe, to be found in a fact I have already noted (p. 46), namely, that unit-

Fig 9 Ovary of Three-Days'-Old Rabbit, showing Formation of Egg-Clusters.

Following von Winiwarter, Miss Lane Claypon holds that the primitive ova (*b c*) are derived from the germ epithelium, *a* (Lane Claypon)

characters, when in the propagative part of the developing zygote, according to the modification of Mendel's theory I have advanced (*vide* p. 43), rearrange themselves according to the curve of probability. As we have already seen that the Mendelian ratio of 1 : 2 : 1 is the expression of the probability of $(A+a)^2$ of two contrasted unit-characters when plants containing them are crossed, I therefore urge that in the primitive germ-cells, while they are undergoing the phenomenon of mitosis in the sexual glands, *the determinants of the unit-characters in them are being arranged according to the Law of Probability*, just as the unit-characters are segregated or rearranged in the zygote afterwards in Mendel's crossing experiments.

We have seen, further, that the primitive germ-cells prior to fertilization each lost half of its chromosomes, thus becoming a gamete; that these gametes unite, and by forming the zygote, restore the chromosomes to their correct number. Now, if in the pre-maturation of the ovum, as it is called, that is, in the mitosis of the primitive germ-cells in the

ovary, there has been a rearrangement of the determinants of the unit-characters, according to the Law of Probability, we have in the throwing off of chromosomes from the primitive germ-cells, before they become gametes and conjugate to make the zygote, a further means of variation (*vide* Fig. 4, p. 40). When the polar bodies have been thrown off there is no evidence that the same characters or determinants for the unit-characters are thrown off each time. Many views as to what the throwing off of the polar bodies mean have been brought forward, but the one that I urge is, that it is a step in the process of producing variation. In the polar bodies thrown off there may be simply ordinary determinants for unit-characters, involving, for instance, the colour of the hair, the stature, the ability or the morality of the individual, and so on; and we will thus get the variations that are so evident, say, for instance, in a family where the children are alike in their resemblance to their strain, but yet differ from one another. There will, however, in certain instances be thrown off some essential unit-character, such

as the factor for local tallness in an organ, or for some developing process or part of the sexual gland, and then the adult will show a striking variation, and it may be what in scientific terminology is unfortunately termed a deformity. The deformities in many instances in mankind form very exact conditions. We may here specially take up the case of men and women with short legs and short arms. Now, it has been found by scientific observers that what is present in these cases is that there is, in such, a deficiency in the early ossification of some of the bones. The bones that are affected are those that arise from cartilage, and that arise early in the development of the embryo. The bones that arise from cartilage later are not affected; for instance, the spine is of the average length. The bones also that arise from flat sheets of connective tissue, *i.e.* in membrane as it is called, as seen in the bones making up the vault of the skull, are not affected, and therefore we may urge, that one explanation of this short-legged, short-armed variety of the human race may be, that in the polar bodies

there may have been thrown off in them, half of what determines the growth of the bones arising from cartilage in an early stage of development. Now, such short-legged, short-armed people, technically termed Achondroplasiacs, are constantly turning up, not in very great frequency, but one sees them fairly often (I have personally seen about nine), and one asks, What about heredity in them? These deformities can become hereditary, and they do so in this way. When the polar bodies are thrown off containing this special unit-character for length of limbs that I have explained, the future gametes of this deformed person are formed early from this variation-zygote which gave rise to his peculiar development. Only some of his primitive germ-cells, however, do not possess the necessary determinants for length, while others have it; and if some of the former chance, afterwards, to be used in fertilization, the deformity would thus be transmitted to some of the offspring. Some of the parent gametes would, however, contain the determinants for normal length, and

the deformed parent could also have children who were normal in their development in this feature.

I might give other instances where this principle applies, but add only one, as the unit-character for length or tallness is probably one of the most important in development. There is a deformity known as brachydactyly, where the hands are short and stumpy, and we may suppose that here there is a local loss of the determinants for length in the middle phalanx. It is, however, represented by a shortened portion, which has become firmly united to the end phalanx of the fingers. The determinants for the unit-character causing the length of one phalanx, the middle one in this instance, must be excessively minute, and might well be thrown off altogether. Now let us suppose that the first brachydactylous ancestor had the determinants of the unit-character for length of the middle phalanx of the finger thrown off completely in the polar bodies of a fertilizing gamete, his after-marriage to an individual where this was present would give him 50

per cent. of a race with normal hands, and 50 per cent. with abnormal hands, approximately half and half; the same percentage as the heads and tails of a penny tossed a sufficient number of times. The results in a series of relations in whom brachydactyly is a variation have been found by Drinkwater to be practically 50 per cent. of normal handed and 50 per cent of brachydactylous persons.

I may sum up, therefore, by saying that variation occurs probably as the result of the following changes. The primitive germ-cells which give rise to the gametes are derived from an early division of the zygote, and travel through the organism to the sexual gland without undergoing any mitosis, that is to say, without variation in their structure. In the sexual gland they undergo mitosis, which means, as I have already explained, variation in the determinants of the unit-characters, according to the Law of Probability. Probably two kinds of ova and spermatozoa are formed then, but what division of unit-characters is in this way given is not known,

although I have suggested it in another paper.[a] When the gametes unite, we get half of the varied chromosomes thrown off, and then when the zygote with its proper number of chromosomes is formed, we get the phenomenon of Mendelism, by which the unit-characters are distributed in the zygote, again according to the Law of Probability; so that by all this we get in subsequent generations organs following the curve of probability in their anatomical condition and function. What biometricians may make of this speculation I do not know, but the amount of variations that may arise from it seems to me enormous.

There is an obvious criticism, however, that must be faced, namely, that this puts variation by environment or other extrinsic causes quite out of the question. Of course one is prepared for that, as Weismann's contention that acquired peculiarities are not transmitted, is now generally accepted. This theory, therefore, does away with that

[a] "Mendelian Action on Differentiated Sex," *Proc. Roy. Soc. Edin.*, 1909, and *Edin. Obst. Trans.*, 1908–1909.

benevolent and amateur theory of Variation and Evolution, which would make environment almost everything, and suppose that as the result of a placid, virtuous, and non-stimulating upbringing, the child with a heredity of passion, energy, and genius—like Byron, for instance—could be domesticated and led to choose a peaceful and negative existence. Variation is really beyond the reach of the individual, and we may say fortunately. Just imagine what our race would be if all the noisy extremists—journalistic, educational, theological, and scientific —were able to train up the unfortunate youth of the race according to their peculiar ideas, the product, to use Lord Westbury's sarcasm, of what "they are pleased to consider their minds."

It may be said that the intrinsic theory is really a scientific basis for Calvinism or Fate; and when one thinks it over it is evidently the best thing that could happen. By it we have an enormous amount of variation allowed for, and thus the average results come out with the same curve. It is well known

that in the fertilization process of the lower animals, the amount of gametes used in the process is out of all ratio to the immediate necessities: the possibilities of variations are enormous, as we have seen, and this simply means that nature has minimized the variations of an unfortunate kind that must arise, by the enormous number of chances against them, owing to the huge number of gametes engaged in fertilization and the previous variation changes they experienced, in the various stages of their development.

It must not be thought that on this view a *laissez-faire* policy should be taken in regard to the upbringing of our race. It must be recognized that they have also in them some normal tendencies of a dangerous nature, and often an innate hatred of discipline that require careful watching. The rôle must be to guide, advise, evolve the healthy body and healthy life, all the while remembering that what is innate will show itself even to destruction. Who can control his Fate? Man has in him, however, a will-power, and the example of the great Sages of the world

to guide him aright, and this makes him more than a mere automaton.

He is thus purified by his experiences, sad though many of them have been, and may emerge from the furnace of Life with higher ideals and purer aims.

The theory I advance does not clash with Mutation.

To *Mutation* we must now devote a little space. We have seen that Darwin, in investigating the Origin of Species, attached the greatest importance to the occurrence of, and gradual strengthening of, variations; and he held that this smallness or minuteness of the variations was a crucial point in his theory. Big differences of variations he did not deny, but he laid very little weight on them, and was strongly impressed with Fleeming-Jenkin's criticism that single variations would very likely be swamped in subsequent crossing. St. George Mivart also urged the difficulty of minute observations being preserved at first unless they were of utility. The occurrence of large variations was, however, known, and the

special instance, an historical one, is that of the Ancon sheep—a short-legged variety of sheep which appeared suddenly in America and bred true. These were of advantage in enclosed districts, as their agility was diminished, but the introduction of the Merino sheep with its abundant wool led to their neglect and extinction. That big variations, however, should so arise was not considered of any very great importance, until recently de Vries of Amsterdam startled the scientific world by showing that in a certain American species of flower, *Oenothera Lamarckiana*, which had run wild at Hilvershum in Holland, he found distinct and well-marked species arising in a generation, that is, that nature in this case had made a distinct leap in originating a species instead of the slow, gradual changes on which Darwin laid so much stress. Mendel's work enables us to understand this clearly. In what has gone before it will be seen that importance has been attached to the throwing off of chromosomes, with causal determinants in them, from the gametes prior

to fertilization. This means that variations arise by such a loss, and are transmitted in the way already explained. Now this sudden occurrence of a species, what de Vries has termed a Mutation, may be looked on as being due to a marked loss of unit-determinants from the gametes, a sort of landslide as it were. We may therefore elaborate further the idea already advanced as to the origin of variations and their transmission. Probably both minute and gross variations occur in plants and animals, the former being those of Darwin, the latter those of de Vries. When the gametes have been so altered by such reduction, the formation of the gametes from these variation zygotes will transmit both minute and gross changes. A simile may help us to understand this. In Scotland one can build a house on land if a yearly rent or feu is paid. Landlords, however, usually put in the deeds that every twenty-five years double the amount of feu-duty is to be paid, a so-called duplicand. The ordinary feu-duty is therefore analogous to the minute variation or

mutability; the duplicand, to the gross one or Mutations, and both are transmitted. Whether they become permanent will depend on their nature and environment. The question of utility settles their survival, and de Vries' work is thus another great stride in the direction of the settling the true Mechanism of Evolution. Its relation to Mendelism is interesting. De Vries defines his mutation as involving that—(1) New species arise suddenly without transitional forms; (2) they are, as a rule, absolutely constant from the moment they arise; (3) they are elementary species, and not varieties; (4) the new elementary species appear in large numbers at the same time; (5) the new characters have nothing to do with individual variability. These, as we have seen, follow Quetelet's law; (6) the mutations are indefinite, and may take place in every conceivable direction; finally, the mutation appears periodically. De Vries in his mutation theory states that it also involves the existence of independent units in the plant and animal, and this is Mendel's great

discovery of autonomous unit-characters. It was de Vries' work, and that of Correns and Tschermak, that led, through a journalistic reference, to the discovery of Mendel's work; and this is not the least of the services of these three investigators, for which all biologists owe them gratitude.

The evolutionist must therefore be an eclectic: must not pin his faith to one mechanism, but take from each what is exact and true. In this way only can progress be made, and all the friction of faction, the narrowness of rigid schools, be avoided. What is true must stand—*that* is a law of nature; what is false will go; and one must recognize that in all advances both are present, and only the smelting of accurate observation and sane and just criticism will give us the pure metal of Truth.

VI

Heredity

"Destiny touches us with magical finger, long before consciousness awakens to the forces that have been set to work in our personality, launching us into the universe with country, forefathers, and physical predispositions, all fixed without choice of ours."

MORLEY'S *Rousseau*, i. 10.

VI

Heredity

By Heredity we understand the fact that like breeds a striking approximation to itself, or that in progeny and their parents and ancestors there are, as a rule, so many common unit-characters present, that the descent of the progeny can be traced in the ancestral line.

We have now to consider some points in Heredity, and the question to be discussed at present is the probable mechanism of heredity in man,—the way in which Heredity is brought about.

The question of Heredity has been in all ages one of mankind's problems, one on which the great minds of the world, known and unknown, have deeply pondered; and there have therefore grown up certain

opinions on the subject, a folk-lore of the highest scientific interest. The early views of the influences moulding man and his destiny, were that it was due to the immediate action of the Creator's will. The sins of the father were visited even to the third and fourth generation (Ex. xx. 5), while Paul states it clearly in his "Therefore hath He mercy on whom He will have mercy, and whom He will He hardeneth" (Rom. ix. 18); and in his "Hath not the potter power over the clay, of the same lump to make one vessel unto honour and another to dishonour?" (Rom. ix. 21). The whole Bible is permeated with this idea of Divine direct causal immanence in man's lot. All this is expressed in the Calvinism on which so many hardy Scottish generations have been prosperously reared, and there must be many among us who have heard thundered from the pulpit the doctrine that, despite all one could do or believe, "few were chosen" to eternal bliss. These hard sayings do not seem to us now so spiritually nutritive as they were in earlier times, and probably no lines did more to

destroy, in Scotland, extreme Calvinistic views than Burns' verse, when he speaks, in Holy Willie's hypocritical prayer, of God as one who

> "Sends ane to heaven an' ten to hell,
> A' for Thy glory,
> And no for ony guid or ill
> They've done afore Thee!"

Calvinism was only scotched by this, not killed, and Evolution, as we shall see, does not give the *coup de grâce*, but rather a modified support to Calvinism.[a]

What countenance do modern views of Heredity give to what are sometimes rashly considered the exploded views of mankind on such a deep problem? There is, as we have seen, Fate in the germ-plasm, but there is also power for each human individual to make the best of it. It is by no means the strong hand in whist that always wins; it is by no means the large capitalist who always

[a] The following story is true. A Scottish minister, wishing to test the faith of a dying member of his flock, said to her: "Janet, what would you say if, after all He has done for you, God should let you drop into hell?" "E'en's He likes; if He does, He'll lose mair than I'll do," was the answer (*Horæ Subsecivæ*, Second Series, p. 268, 1861, Dr. John Brown).

succeeds, and it is by no means the strong hand of unit-character that is always used wisely.

The lot and future of man are believed by the Mohammedan to be guided by Fate, and Kismet is the word ever ready on his lips. The Mohammedan accepts Fate in his life-time, but Calvinism, on the other hand, relegates its results to the next world, relying on Free Will mainly in this.

Darwin's investigation as to the Origin of Species really involved the question of Heredity. As soon as it was seen that new species developed *from* previous species, that characters were not isolated in species but passed over the artificial boundaries between, the question at once arose as to the transmission of the characteristics *in* the species, that is, the problem of Heredity was formulated. Since Darwin's time the progress in the question has been marvellous, but the advancing circle of light, to use an old simile of Chalmers', seems only to show the equally increasing periphery of our ignorance.

Heredity

We must now try to state what explanations modern investigation can give of the mystery of Heredity. We have seen already that the gametes, which are the bearers of Heredity, are a directly derived part of the zygote at its earliest and unchanged condition. Further, we have seen that the propagative part of man — the gametes—contained in the sexual gland is not influenced by the "soma" and its functions, but is handed on from generation to generation for the perpetuation of the race, and is not utilized in the nourishment of the "soma" itself.[a] To use Galton's simile, the body is the trustee of the gametes' estate, and cannot "intromit," in Scottish legal parlance, with it. An individual is sent into the world derived from a germ-plasma he has had no control over, and his children are in the same way developed from the parental gametes, which (in many cases fortunately) the parents are unable to modify by their own life. Man can therefore

[a] The sexual glands do exercise an influence on body-nutrition, but we need only mention this.

neither choose his parents, nor improve or deteriorate his germ-plasma. The last point may seem too dogmatic. It is possible that alcoholism and inbreeding may so deteriorate the germ-plasma that it may ultimately become degenerate or inert, but on this we have no exact information, although sufficient to convince many of the danger that may result to a strain from a sinful life, and warn us off prolonged inbreeding.

Each individual has thus allotted to him, by his heredity, his faults and his virtues, his talents or his mediocrity, his genius or his mental red-tapeism, and the man is happiest who recognizes this and regulates his ambitions by his capacities. The germ-plasma is the clay, and the mechanism of Heredity the potter.

Can we now give any explanation as to the distribution in a man of his heredity determinants? Probably we can.

The zygote may be considered, in Weismann's terminology, as made up of the determinants of race-heredity and family-heredity—not merely of the qualities of three

generations. These determinants are in the chromosomes, and the remarkable changes, divisions, and reductions that occur in the chromosomes of the germ-cells, gametes, and zygotes, are most probably concerned with changes in the allotment and variation of the determinants. We have no defensible conception as yet of the nature of the heredity determinants, but only of their probable locality, in the chromosomes, and this must be clearly understood. The term "determinant" is merely an algebraic one, the x or unknown quantity, as it were.

We may regard an individual as made up of an immense "aggregate" of characters, or, better, of "unit-characters"—a term, we have seen, that expresses their autonomy. Thus in an individual there are innumerable unit-characters, namely, tallness; skin-colour and texture; eye-colour; factors in growth and development; ability, general and special; character, straight or shifty; morals, pure or debased; and so on. These may be termed the determinates in the developed adult, and are caused by the determinants.

Each of these determinants in the zygote has probably a power of increase in the earliest periods of zygotic life, and the undifferentiated zygote does not merely contain sufficient determinants in its zygote to be causal for the individual, but also (in the portion allotted from it for the propagative part) innumerable and differing determinants of the race, descending from remote ancestors.

How do these determinants act prior to the union of the gametes and after fertilization in the zygote? How, in the members of a race, are they allotted? The members of a family have much in common, but they vary greatly. One may have the highest qualities of genius, some only talent, and a large number average mediocrity. Brothers may be the exact opposite of one another mentally, like the Newmans—the Cardinal, a rigid Catholic bound to human authority, and yet in some respects an evolutionist; his famous brother, a man with an open and free mind: in both, great yet divergent abilities. Many examples of this might be given, but we need not multiply such, and

rather pass on to suggest how it all happens.

We may recapitulate thus. When the zygote is formed there has been a prior reduction or loss of determinants in the primitive germ-cells to form these gametes (Fig. 4, p. 40), and then in the zygote a re-arrangement of determinants, an interchange of determinants in the spireme or coil stage of the chromosomes. The zygote divides into two great parts—the propagative and somatic part. The former is called the primitive germ-cell mass, and is made up of primitive germ-cells, and these are zygotes capable of zygotic development. They ultimately are reduced to gametes, which require to unite with another gamete to form a zygote. The somatic part of the zygote is really one zygote *minus* a propagative part. It develops the soma, and into it the primitive germ-cells travel to form its sexual gland. The gametes in this sexual gland contain different unit-characters: those of the immediate family and those of the race, the oldest being in least number probably;

and thus the chances of an old unit-character turning up are rare, owing to the millions of male gametes present, and the many thousands of female ones. Thus in propagation we must note—

1. That the parents may transmit characters not present in their soma; these are present in their propagative part.
2. Characters may appear in the progeny which have not been expressed in the family for many generations.
3. Far-back characters, not of the species but of its ancestors, may appear, although rarely, so-called Atavism, much better termed "delayed inheritance."
4. If the gametes of the propagative part are modified by reduction, then, as the gametes form the zygote and the primitive germ-cell mass is derived from the zygote, we here get a key to the origin of variation — the yet unsolved problem of Evolution.

5. It is probable that in the redistribution of characters in the development of a zygote, girls follow, in the main, the father in body and mental development to a larger extent than boys do, and *vice versa*; but any proof of this is too technical, and not as yet sufficiently investigated.
6. We have seen that in F^2 of the tall-dwarf crossing, one-quarter of each bred true to its selected recognizable unit-character. This raises the question whether in man a special character could not be made permanent or eliminated. To do this we must get the selected quality pure in the propagative part, and thus it becomes true in the somatic part. We are still on the threshold of this matter, however, and any speculation as yet would be unwarranted. We may note, however, that Biffin has bred by selection and crossing a wheat immune to the disease known as "rust," *i.e.*, has obtained this immunity as a coupled unit-character

breeding true. It is improbable, however, that this can be applied to humanity, *i.e.*, we could not deliberately so breed and select that a proportion of a race could be rendered immune to tuberculosis, for instance.

What law regulates the re-arrangement of determinants or their throwing off is as yet unknown, but it, at any rate, follows the law of frequency. Thus intrinsic re-arrangements of what is causal to the unit-characters in individuals take place in each fertilized zygote, between its propagative and somatic parts and in the maturation of the germ-cells.

What practical deductions can be drawn from this? We usually trace resemblances between children and their parents. This is true only to a certain extent. Galton puts the contributions as $\frac{1}{4}$ from each parent, $\frac{1}{16}$ from grandparents, and $\frac{1}{32}$ from great-grandparents. But Mendelism has thrown a fresh and disturbing light on this law, and the new work on the origin of the gametes has cast the whole matter into the melting-pot.

Parents thus can transmit unit-characters

their "soma" does not contain, but these have been in their gametes. We must again insist on the essential difference between the propagative part of the individual and his "soma." The tall plant of F^1 gave rise to a quarter of dwarfs, although it had no dwarfness in its soma, only in its propagative part. Thus the capacities of a child may differ greatly from those of its parents, and may not, in the ignorance of most of mankind as to their ancestors, be fully traceable in the known ancestral line.

The boy may thus not have the power to follow in the paternal footsteps, to the great grief of the worthy but unreflecting parents. Their duty clearly is not to force him into their groove, but to give him a groundwork education, to see where his talents lie, and to let him develop them. Thus, in accordance with Jewish custom, the famous Spinoza lived the simple life on the pittance obtained by grinding lenses, and followed the philosophical bent expressed in his immortal works. The instance of St. Paul will rise to everyone's recollection. If the path he

aspires to follow, leads through a picturesque but unremunerative country, he should be advised to take his supplies with him in the form of some occupation that affords him the necessary bread, butter, and water. If he throws this advice away in his enthusiasm, he may then starve in the desert, with the probable encouragement that someone else may make a living by writing a picturesque biography of a neglected genius.

The problem, however, that almost all parents have to settle, is how their children can best use ordinary talents in view of the great preponderance of average ability in offspring. In most cases the ordinary profession or trade suffices, with a careful eye to the formation of character.

If a child possesses that quality known as Genius, inexplicable as it is, it will best be left alone. Few parents, and certainly no university, have ever recognized or fostered genius. The mother[a] usually has had the

[a] Of David Hume, the pride of Scottish philosophy, his mother said, "Our Davie's a fine, good-natured cratur, but uncommon waik-minded" (*vide* Huxley's *Hume*, p. 2).

surest instinct; but for one Ruskin fostered by parental devotion, there have been hundreds hindered. The consolation is that genius, if stable, can make itself felt, however many obstacles are thrown in its way, and can from these very obstacles get the material on which to exercise its power. Scott had to toil at uncongenial legal work, but one sees how in Jeanie Deans' misfortunes, in Bartoline Saddletree's lucubrations, and in the famous scene before George II's wife, his legal and historical knowledge were utilized to the full, giving the nectar whose honey has delighted, and will continue to delight, untold generations.

Louis Stevenson's life affords much food for thought. The delicate bright boy, now the St. Louis of the young literary Presbyterian cult, must, of course, follow in the footsteps of the great lighthouse engineers of the father's family. The literary ability from the maternal side was transmitted and exaggerated, with, as a result, the little difficulties of Stevenson's early manhood. Conventionalism triumphed, and engineering

first, and then law, were his lot. He passed as an advocate, but the Parliament House, the national mausoleum of the talents of so many of the upper-class youth of Scotland, saw little of him, just as Fleeming-Jenkin's class saw less. One could hardly imagine him dexterously cultivating the acquaintance of the writers and solicitors who might send grist to his mill, or wheedling or bullying an unfortunate witness, or dexterously setting out the view that might appeal to the idiosyncrasies of the Bench. Yet he could not have written his famous books without his legal knowledge and the experience garnered in lighthouse travels in the West Highlands, as any one who reads his essays and novels may easily note.

Our universities have not hampered the budding genius: they have simply ignored him. Carlyle learned little at Edinburgh University, and Darwin less. Henslow saved Cambridge from reproach in Darwin's case, but what can Oxford and Cambridge say of their treatment of Adam Smith, Shelley, Byron, Palmer, and many others?

The universities, unfortunately, cater for average ability and abnormal cramming power, and their heads have been usually more conspicuous, as a rule, for their business abilities and manipulative dexterity in wire-pulling, in the interests of the university, of course, than for encouraging the progress of science and learning. Who would have known of a certain St. Andrews Principal had it not been for his dexterity in excluding Carlyle from a Chair and substituting someone whose promotion gave rise to a convenient re-arrangement?[a] Of course a new era is dawning now, and we may look forward to great developments in the present and future.

From what has been already said, especially in the chapters on Mendelism and Mendel, it is evident that as unit-characters are autonomous, *i.e.* transmitted in certain

[a] Froude tells us of this in his *Carlyle's Early Life*, i. 434. Nicol was "cautious and prudent, possessing neither genius nor learning, and without reverence for them. It was not unlikely, therefore, that he had already cast his eyes on some decent, manageable, and judicious priest for the office."

ratios unchanged, we do not get bad qualities improved or good qualities toned down in heredity transmission. This is the greatest result of Mendel's work. The upright woman who marries the rake will neither reform him nor have children who are all improved by the cross. Perhaps all the first generation may show his dominant taint, and it may be that only as a grandmother she will see the partial fruits of her self-sacrifice.

After all, this fact in transmission is right. Nature, in this, "may seem a beast, but she is a just beast." Many may mourn over it, but they look only at the improvement of bad character by what they would call a judicious crossing; they forget the deterioration of the good that their theory involves, and that a uniform and hateful mediocrity would follow their benevolent ideas. Nature is wiser than the pious Mrs. Grundy, and conserves the good and bad, leaving the bad to be eliminated by the checks their shiftlessness, crime, and dissipation impose.

The question of the good effects of in-

breeding has been much discussed. In-breeding has been condemned, and, as in the marriage of cousins, credited with disastrous results, such, for instance, as imbecility and deaf-mutism. Statistics do not fully bear this out, and stock-breeders when they have a good stock inbreed successfully. They have noted that a cross, while it may introduce good characters, may also introduce unanticipated bad ones, and are therefore careful in disturbing a good strain. The common-sense seems to be this. Inbreeding parents have more characters common to both, and more chance of such turning up in the progeny. All stocks have some bad unit-characters, and thus these may turn up more frequently when inbred. Fresh blood, as we say, will introduce fewer common characters, and there is less chance of bad ones reappearing; but they may still appear later, if less seldom, than in cases of in-breeding.

There is a limit to improvement by crossing. After a certain increase in the number of heads of wheat and the size of the grains,

the agriculturist and breeder can only just keep this up. He cannot breed wheat grains the size of beans. Tall men and tall women do not breed taller men and taller women in each succeeding generation, but the tendency is to pass to the average race size : Galton's theory of filial regression. Unless the new character is segregated in sufficient numbers, the greater preponderance of average qualities will swamp it.

The cause of the general improvement in cross-breeding is best explained by Mendelism. In a Mendelian crossing, attention is fixed on the contrasted unit-characters only. It must be noted, however, that there is—there must be—a similar ratio-change in the common qualities, and thus if one of the crossing parents has greater vitality in its unit-characters, the result will be an improvement in the vitality of many of the progeny. It follows from this that, after all, a good stock is the great thing. Mankind cannot act as breeders do, who breed from the best and relegate the unpromising to the feeding-pen ; it breeds indiscriminately, tinkers up the

bad progeny, hampers, often from jealousy, the success of the good; and the result is the polymorphic ability, morality, and physique, which constitute the noblest work of the Creator.

VII

Heredity in Disease

We can neither choose our Forefathers nor improve them.

"With antecedents,
With my fathers and mothers, and the accumulations of past ages,
With all which, had it not been, I would not now be here as I am."

WALT WHITMAN.

VII

Heredity in Disease

THE importance of Heredity has been so much exaggerated in regard to disease that many must have regretted the loss of the old Calvinistic view as to its causation. When misfortune came in the shape of disease, or malformation, or mental defects on the part of the children, the Calvinist braced himself to the inevitable trouble and set it down to the Creator's will. He had, at any rate, the consolation that he himself was not responsible, and that it was not for him to question the wisdom of a Higher Power. Nowadays we look at the matter perhaps more scientifically, and in disease see either a tendency in our strain, or some evidence of neglect on our own part; or in cases of imbecility, mental disease, and so on, eagerly

scan our heredity as far as it is possible, and feel mortified that we have in it such weak points. We are, in fact, ashamed of our misfortunes. This is well seen in the inhabitants of our asylums. It is the poor, who know nothing of Heredity, except that they attribute mental misfortune too often to the parents being too "sib," as they say, who are the most faithful visitors to their unfortunate relations and offspring. The rich first bewail the unwelcome facts, then become careless in their attendance, and finally end by forgetting the unfortunate sufferers altogether. An eminent alienist, indeed, has said that among those who do not forget the unfortunate is the faithful unmarried female relative, that paragon of perfection in illness, and the surest source to the medical man for an accurate and unsparing account of the family failings. It is unfortunate, therefore, that Heredity has introduced a certain amount of despair, or even of callousness, in those who push the present results to their apparently logical conclusion.

The fact that our processes and functions

are governed by the definite laws of Heredity is, however, by no means a discouraging one. In the first place, it must be noted that the purity of the strain in the germ-cells and its non-affection by the soma, is a most hopeful feature of our Heredity. In the second place, while malformations do turn up automatically, as I have already explained,[a] they are at the extreme end of the curve of frequency, as it were, and their proportion to the general average of results is really a very small one. Then, further, it is to be noted that a great many diseases which were considered hereditary are now known not to be so, and this is well emphasised in the case of tubercular disease, which was once supposed to run in families. It must be kept in mind, however, that the *Bacillus tuberculosis* is really ubiquitous, and pathologists tell us that in every post-mortem they find some traces of a previous slight bacillary infiltration.

The outlook as to Heredity in regard to many diseases is, therefore, distinctly hopeful. When there has been a run of tubercular

[a] See also Chapter V. p. 85.

disease in a family, they have probably infected one another. Before Koch's discovery, the idea of one tubercular member in a family infecting another was scouted in this country, although the contrary was held by Italians, for instance.

One curious speculation must not be forgotten. Civilized races are to a certain extent immune to tuberculosis. The time might come when all tubercular infection may be banished from our shores. Immunity must then cease, and accidental infection will wreak its vengeance as it has done among peoples virgin to the bacillus. Thus Louis Stevenson tells us, in his *In the South Seas*, what may happen to a population virgin to disease when it comes among them. "The thought of death, I have said, is uppermost in the mind of the Marquesan. It would be strange if it were otherwise. The race is perhaps the handsomest extant. Six feet is about the middle height of males; they are strongly muscled, free from fat, swift in action, graceful in repose; and the women, though fatter and duller, are still comely animals. To

judge by the eye, there is no race more viable;[a] and yet death reaps them with both hands. When Bishop Dordillon first came to Tai-o-hae, he reckoned the inhabitants at many thousands; he was but newly dead, and in the same bay Stanislao Moanatini counted on his fingers eight residual natives. Or take the valley of Hapaa, known to readers of Herman Melville, under the grotesque misspelling of Hapar. . . . The tribe of Hapaa is said to have numbered some four hundred, when the small-pox came and reduced them by one-fourth. Six months later a woman developed tubercular consumption; the disease spread like a fire about the valley, and in less than a year two survivors, a man and a woman, fled from that new-created solitude. A similar Adam and Eve may some day wither among new races, the tragic residue of Britain. When I first heard this story the date staggered me; but I am now inclined to think it possible. Early in the year of my visit, for example, or late the year before, a first case of phthisis

[a] *Query*, virile.

appeared in a household of seventeen persons, and by the month of August, when the tale was told me, one soul survived, and that was a boy who had been absent at his schooling. And depopulation works both ways, the doors of death being set wide open and the door of birth almost closed. Thus, in the half-year ending July 1888, there were twelve deaths and but one birth in the district of the Hatiheu. Seven or eight more deaths were to be looked for in the ordinary course; and M. Aussel, the observant gendarme, knew of but one likely birth. At this rate it is no matter of surprise if the population in that part should have declined in forty years from six thousand to less than four hundred; which are, once more on the authority of M. Aussel, the estimated figures. And the rate of decline must have even accelerated towards the end" (p. 26).

Probably all heredity in the variations we term malformations begins, as already said, by the loss of some of their causes or determinants when the polar bodies are thrown off prior to fertilization. They are thus in some

of the gametes derived from this variation zygote, and are thus transmitted. They are inevitable: the unfortunate, or fortunate in some cases, have had this sifted out into their lot by law, and there is no more to be said. They may preponderate in some families, however, for reasons not well understood.

Some rare conditions do run in certain families, and one is that of hæmophilia, the technical term for the disease of those who are "bleeders." These unfortunates bleed seriously from an insignificant scratch, or after a slight operation. The condition is not present in the soma of the female, but is transmitted to the son. The simplest explanation may be that the unit-character preventing hæmophilia is absent in the sex-gamete of the male, or in the non-sex ovum of the female, and thus the males bleed. Many curious facts come up under this head, but the above example is sufficient at present.

Now to a practical point. If Heredity is of such evident importance, should not some attention be paid to it in actual life. The idea is often mooted that marriages should be

so arranged, as that the bad qualities of one of the parties should be counteracted by good and opposing qualities in the other. Thus the rake should have the pious bride; the careless, unbusinesslike woman the precise financier; the narrow-chested heir of a degenerate race, one of Charles Reade's broad-chested, wide-hipped peasant girls, and thus the balance of error redressed. Unfortunately, the bad qualities and good qualities will each have their ratio and will not counteract one another, although the rearrangement of good and bad common qualities may help. Probably the sons in such a case, as following the mother, will be, in some respects, improved.

What makes this planning of suitable marriages not feasible is, that it is not Nature's way. Prince Kropotkin in his fascinating *Memoirs* tells graphically how an imperious Russian landowner arranged his serfs' unions.

"A landowner once made the remark to another, 'Why is it, General, that the number of the souls on your estate increases so

slowly? You probably do not look after their marriages.'

"A few days after, the General ordered that a list of all the inhabitants of his village should be brought him. He picked out from it the names of the boys who had attained the age of eighteen, and of the girls just past sixteen—these are the legal ages for marriage in Russia. Then he wrote, 'John to marry Anna, Paul to marry Paráshka,' and so on with five couples. The five weddings, he added, must take place in ten days, the next Sunday but one.

"A general cry of despair rose from the village. Women, young and old, wept in every house. Anna had hoped to marry Gregory; Paul's parents had already had a talk with the Fedótoffs about their girl, who would soon be of age. Moreover, it was the season for ploughing, not for weddings; and what wedding can be prepared in ten days? Dozens of peasants came to see the landowner; peasant women stood in groups at the back entrance of the mansion, with pieces of fine linen for the landowner's

spouse, to secure her intervention. All in vain. The master had said that the weddings should take place at such a date, and so it must be.

"At the appointed time, the nuptial processions, in this case more like burial processions, went to the church. The women cried with loud voices, as they are wont to cry during burials. One of the house valets was sent to the church, to report to the master as soon as the wedding ceremonies were over; but soon he came running back, cap in hand, pale and distressed.

"'Paráshka,' he said, 'makes a stand; she refuses to be married to Paul. Father (that is, the priest) asked her, "Do you agree?" but she replied in a loud voice, "No, I don't."'

"The landowner grew furious. 'Go and tell that long-maned drunkard' (meaning the priest; the Russian clergy wear their hair long) 'that if Paráshka is not married at once, I will report him as a drunkard to the archbishop. How dares he, clerical dirt,

disobey me? Tell him he shall be sent to rot in a monastery, and I shall exile Paráshka's family to the steppes.'

"The valet transmitted the message. Paráshka's relatives and the priest surrounded the girl; her mother, weeping, fell on her knees before her, entreating her not to ruin the whole family. The girl continued to say, 'I won't,' but in a weaker and weaker voice, then in a whisper, until at last she stood silent. The nuptial crown was put on her head; she made no resistance, and the valet ran full speed to the mansion to announce, 'They are married.'

"Half an hour later, the small bells of the nuptial processions resounded at the gate of the mansion. The five couples alighted from the cars, crossed the yard and entered the hall. The landlord received them, offering them glasses of wine, while the parents, standing behind the crying daughters, ordered them to bow to the earth before their lord."

This is a caricature of Nature's method. Her agent is Cupid, who is not an archer

but a hypnotist, who places the lovers in an atmosphere where the commonplace in both is idealized, the actual defects ignored, where the rays of disillusionment do not penetrate. To the married, who rightly keep up this condition, the often asked question, "Is Marriage a Failure?" will seem an impertinence.

Nature is right, as she always is. The intimate and constant relations of husband and wife would soon become strained if the bond were only a financial one or one where the desire for position or ambition had flicked the string. Louis Stevenson's old shepherd was better advised. He had been more than once married and when teased as an authority on Love by the giggling feminines, and asked which of his wives he liked best, used to say that the first spouse made such a big hole in his affections, that the others slipped in easily. Few probably will be able to say, like an old Scots doctor, that he married the first time for love, the second time for position, the third time for money, and that the first was the success.

Truly a fortunate man! Nature's method, that of a marriage under a strong idealized passion is the best. Could marriage results as to happiness be plotted out, we would doubtless have the probability curve—a high-graded average of moderate happiness, and a low one for the extremes of misery and bliss. Those who in their matrimonial boat have always a calm sea and sunny skies will not develop happiness—that is given to the gallant sailors who face all disagreeables courageously and sail on "with shroud and tackle damaged," but with their loyalty and affection unshaken.

Legislation as to marriage on scientific lines would be a misfortune. We know too little to be able to do anything safely. One might indeed say, following an eminent Episcopal wit and orator, that it would be happier for a race to be free and diseased rather than healthy and enslaved. What will influence the future race will be the slow and sure growth of sane and healthy public opinion on the matter of Heredity. It is remarkable the influence that Koch's dis-

covery as to tuberculosis has had on the objectionable habit of expectoration. No law could have put it down; now it is a vanishing habit. Perhaps, in time, Cupid will become educated on modern lines, and, before he shoots, look up the lovers' dossier, and return the arrow to his sheath, if he notes the black marks of a bad heredity. But is not love, according to folk-lore, blind?

VIII

The Community of Bees

" Protenus aërii mellis coelestia dona
exsequar : Hanc etiam, Maecenas, adspice partem.
Admiranda tibi levium spectacula rerum,
magnanimosque duces, totiusque ordine gentis
mores, et studia, et populos, et proelia dicam.
In tenui labor ; et tenuis non gloria, si quem
numina laeva sinunt, auditque vocatus Apollo."

VIRGIL, *Georgics*, IV.

" The honey harvests scattered from the skies,
Aerial gifts of heaven at last I sing,
Vouchsafe, Maecenas, to my latest task
The gracious benison of other days.
Come with me, and I'll set upon the scene
A wondrous drama of a pigmy world,
Citizens, soldiers, lords of high degree,
And what their character, and what their craft,
A very nation with a nation's life
In due array shall pass before thine eyes.
Trivial the task, but large the meed of praise,
If adverse fates permit, and thou but smile,
Mighty Apollo, on thy suppliant's prayer."

LORD BURGHCLERE.

VIII

The Community of Bees

THE life of the honey-bee has attracted the attention of mankind from the earliest ages, and biblical, classical, and scientific literature are full of allusions to it, and to the superstitions connected with it. Yet some of its features are still as little understood as when Samson propounded his riddle, and Virgil sang in his *Georgics*; and in regard to the nature of bee-sex and the method of its production, modern embryology can give no exact or even approximately exact answer.

The beehive is really a socialistic community, where the questions as to specialisation in the propagation and rearing of the race, its hygiene and colonisation, have long been settled, many æons probably before man had emerged from his primitive condi-

tions. Maeterlinck has considered these questions in his glowing prose, but even the sober discussion of what actually happens in bee-life, takes one at once into the region of apparent romance, and no fairy with a wave of her wand can produce more remarkable transformations than the honey-bee in its well-known abode.

A modern hive with an active and fully developed "stock," as it is called, contains one queen, thousands of workers who are sterile females, specialised for domestic, hive, and outside work, and the defence of their home ; and many stingless males, the drones, whose sole function is to live at ease and with the aims of Mr. Turveydrop, until a few of their number have mated with the swarming virgin queens. They are then ruthlessly driven out of their home by the workers who do not trouble to sting them but give them their *congé* by snipping off one wing.[17] This massacre usually happens in August and is done most thoroughly.

The queen is a perfectly developed female, although long considered a male, as, for

instance, by Aristotle; and this explains Shakespeare's famous if inaccurate line:

"They have a King and officers of State."

Human regal rule in the sixteenth and seventeenth centuries was so jealous and suspicious, that the question of the sex of the apparent ruling bee was usually judiciously determined as agreeing with that of the reigning monarch.[18]

The queen's great function is the laying of fertilized eggs to produce queens and workers; as well as, it is said, of unfertilized ones, to produce drones. She is of the same build as the worker-bee, but larger and longer, with wings relatively shorter to her body, and some other features we need not describe. She has a scimitar-like sting, but she uses it only against a rival or to destroy the virgin queens in their royal cells. Before a virgin queen in the hive issues for her nuptial flight, the workers are said to prevent her doing the latter; but, after her return to the hive, fertilized, they give her her will, and, like an Oriental potentate untrammelled by

civilized interference, she destroys all rivals by a thrust with her sting in the lateral aspect of the body, where the openings of the air tubes lie.

The queen spends her short, strenuous life of two years[a] or so, solely in the hive, with the exception of her nuptial flight and its preliminary trials, and the time when she may lead, usually in June, a "swarm" from her teeming home to form a fresh colony. In the now diminished "stock," queen-bees have been reared in the special queen-cells (*vide* p. 175), and one of these now leaves the hive in a fresh swarm and is mated outside by one of the drones, the swiftest and strongest. When this swarm is hived in a new home, she begins and carries out the life to be sketched in a little.

The spectacle of a "swarm of bees" on a bright June morning, as the writer saw it in a town garden, perched on the cliff bounding the magnificent valley spanned by the Dean Bridge, would have stirred even the prosaic mind, for soul he had none, of

[a] She has been known to survive for five years.

Peter Bell. Instead of leaving their narrow entrance by the usual threes and fours, and, darting off for nectar, they poured out tumultuously, so that even the mere onlooker recognised that the bee had "business on its hand." Circling in the air, they crossed and interlaced in a delirium of love, until, the victor acknowledged, they settled prosaically below their old home, and, clustering patiently till sundown round their now widowed queen, meekly entered the hive provided for them.

The hive was evidently a teeming one, as a second swarm came off two days afterwards and settled like a huge cone, apex down, on the branch of a small fir-tree in an adjacent garden. There it hung motionless till evening, when it was easily bumped and spooned into a "skep" held below. Next morning they were busy at work as if nothing had happened.

Such a marvel suggests more questions than science or practical skill can answer. It symbolises the power of passion, the daring of colonial enterprise, the struggle

for existence, the acquiescence in fate. After this crisis in hive life, all but the drones settle down to patient work; the queen to her constant duties as the mother of all; the workers eagerly to their unceasing toil and restless life. Only the drones live the life of the lotus dreamers, till their fate comes in August, and they are cast out as cumberers of the hive.

In summer, spring, and part of autumn, the queen traverses the combs with a slow and stately step, evidently seeking for suitable cells. She stops at the one she chooses, and, passing in the greater part of the abdomen, lays an egg. At one part of the laying she makes a slight turn, but the object of this is not known. It is said she may lay as many as three thousand eggs a day.[19]

During all this time, a guard of about a dozen workers face her in a circle, constantly caressing her with their antennæ. The other workers clear away as she walks through the hive, a contrast to their indifference to the ordinary workers and drones, who jostle and climb over one another good-naturedly.

The queen-bee is thus merely the "mother-bee" of the hive and is only actuated by mating furore, or that of egg-laying. She has no rule in the hive; nevertheless her presence and activity in function is everything in its internal economy, as we shall see in a little.

The worker-bees are really the stalwarts in the hive's work. They are sterile females, lay no eggs,[a] never mate, but devote themselves to hive and outside work. Their duties are almost too many to mention. Martha had a leisured life compared with that of a worker-bee. She tends and feeds the developing bee; cleans the cells after the young bees emerge, leaving the cocoons however; removes the dead bees and any undesirable refuse; guards the hive, challenging all who enter; keeps out or stings aliens; ventilates the hive by fanning her wings, for this purpose standing in single or double line with others; tends the queen, forming her bodyguard while she lays eggs, constantly directing and caressing her with the ever-

[a] Worker-bees occasionally lay eggs.

mobile antennæ; fanning her with her wings when she rests. The worker-honey-bee is always alert. If any noise is made, for instance, when the hive is touched or jolted, she at once appears to investigate the cause, and if hungry, woe to the meddler—he will repent. Yet when replete with honey she is not aggressive, and if left alone and not hastily brushed aside, will leave one in peace.

The worker has, however, higher powers, even the settling the question of the hive's policy in emergency. When a queen has been lost or dies, and a new one introduced by the apiarist, the workers may resent this and kill her. They do not, it is said, lift their natural weapon against her, who is as the Lord's anointed to them, but crowd round and apparently suffocate her—"balling" her, as apiarists say. They even rear a queen specially, by means to be described afterwards.

The question of the origin of the worker and the formation of a queen from a worker-bee is still unsolved, but this we shall consider subsequently.

The "drone" is developed in a larger cell than the workers and is a perfect male. He is larger than the worker, of a burly build, and a somewhat lumbering gait. The queen's walk is stately, and all clear the way for her and her guides: the workers actively and purposively make their way over the combs, scrambling over one another; the drone rather lounges about. Sometimes when the workers pass in a rapid current through the tunnels at the comb corners, in play as it were, the drones bustle along with them, like a big boy in the playground among the little ones. On a warm day the drones and workers fly out and sport in the air. The fate of the many hundreds of drones in a hive is merely to provide mates for the few virgin queens reared. He dies in his rapture, and after that his many unsuccessful competitors can only look forward to the massacre of August.

There is too much to be told about bees for one chapter, and therefore the best plan will be to describe what one can see in a modern observation hive, and then supplement it by considering the evolution of the honey-bee.

IX

A Modern Observation Hive

"But now . . . cabin'd, cribb'd, confin'd, bound in."
Macbeth, III. iv.

IX

A Modern Observation Hive

A MODERN observation hive[20] is an oblong box, placed with its long diameter upright. It is 2½ feet high, 4 inches deep, and 18 inches broad. Its two large sides are double glass, the others of wood, and the glass sides are provided with removable shutters. It revolves on a circular disk, and has a ventilating aperture protected with zinc in its top. A shallow wooden trough, seven inches broad and the same in length, with glass above, runs to the outside air, from the lower end of a glass side, through a piece of wood, filling in the gap made by the raised window of the room in which it is placed. In this way the bees get access to the open air, are excluded from the room, and can be easily studied. When the shutters are removed the whole busy life of the hive can be

seen. The conditions of life are to a certain extent modified, and they do not live so strenuously as their garden fellows; but, for all purposes of study, an observation hive is excellent, and, supplemented in other ways, gives ample opportunity for thought and experiment.

When such a hive is examined on a bright, sunny day, the view given us is of a most interesting nature. Three oblong frames are seen placed vertically one above the other, and, within its frame, the honey-combs. The modern apiarist does not allow the bee to make the honey-comb; that would be too costly, consuming, as it does, too much honey, twelve pounds of honey being necessary to produce one pound of wax. He fills in the frame with a sheet of wax, where by machinery the cell outlines have been mapped out. One, in this foundation of fragrant wax, sees accurately the outlined hexagonal cells on both sides, with the cell base filled up by three sloping plates; and the relation of the cells on the two sides is such that a needle put through each of these basal plates in one

Fig 10 A Town Observation Bee Hive

Seen from the outside — the window sash raised

(To face p. 153.

cell, passes into a different cell on the other side. The bee approves of this saving of labour to it, and uses the foundation to build up the rest of the cell depth. This makes the completed cell for honey or brood or pollen. The cells intended for workers are one-fifth of an inch wide and nearly half an inch deep; those for drones, one-fourth of an inch wide, by five-eighths of an inch deep. The queen-cells are specially large, as we shall see. The frames are movable and can be taken out easily. If we now continue our inspection, we see the comb entirely covered with workers and drones, ever on the move —the double claw on each foot enabling them to take a firm grip of the edge of the cell wall, while the oily pad between the claws gives it an equally safe footing on the glass. You note the small worker-bees, the big and heavy-looking drones, and then you look carefully for the queen. In the hive I am describing the workers and drones are hybrids, but the queen-bee is a pure Italian with a golden-yellow body, unstriped, and with a well-marked circular boss on the back of her chest.

Her limbs are large and look powerful. She is thus easiiy seen, and you observe at once how, as the queen advances, the crowd of bees clears away, as it does not to fellow-workers and drones. Around her you see a circle of about a dozen worker-bees, heads towards her, touching her constantly with their antennæ, cleaning her as it were, and perhaps guiding her on to empty cells. Soon she stops, after having previously scrutinized a cell, and, curving the posterior half of her body ventrally, passes it into a cell and deposits an egg. While doing this she makes a slight turn. It is advantageous for her to have short wings, as this allows her more easily to insert the greater part of her body into the cell. In a few seconds she withdraws, and then passes on to the next empty cell. The queen lays unfertilized eggs for males, and fertilized eggs for workers, it is said. The drone-cell is a little larger than the worker's. The worker-egg is in a smaller cell, is closed in ultimately at the roof by wax, whereas the queen-cell is almost as large as the last joint of one's little finger,

and is left open at its unattached end. The egg producing a queen, said to be a worker-egg, is supplied with what is termed royal food. How the queen knows a drone-cell and a drone-egg, how she knows a worker-cell and a worker-egg, and how mere food makes all the difference between a queen and a worker-bee, are still mysteries. There is, however, a crowning mystery, namely, the opinion that the drone, a perfect male, is not developed from a fertilized egg, but is merely an egg or ovum of the queen's sexual gland, uninfluenced by the gametes of the drone, and developed into a drone in the drone-cell and without any special food other than that the worker-eggs receive.

I have spoken of the drone, the male bee, and must explain a few points. When the queen and drone mate, in the open air, never in the hive, the gametes of the drone, many millions in number, are passed into the body of the queen. They are "stored" in a special pouch, the spermatheca, which opens into the duct along which the queen's egg passes when she

lays, and, as it passes, one male gamete fertilizes it. The egg for a drone is said not to be fertilized, *i.e.*, when the egg passes the spermatheca, no male gamete emerges to blend with it; that for a worker or queen is fertilized by a male gamete. This view of the drone's origin is termed "parthenogenesis" or virgin birth. It is almost universally held, and many facts seem to corroborate it, if these are true facts, which is doubtful. One simple fact, however, is difficult to get over, namely, that when an Italian queen mates with a black drone, some of the progeny of drones exhibit paternal markings. This could not happen if the drone were produced from an unfertilized egg of the queen. Present views may be accepted, however, until fresh investigation clears up the matter.

If one now looks at the exit tunnel, on a sunny June day, a most busy throng is seen. Incoming bees alight on the outside board with their baskets[a] packed with an oval

[a] The so-called-basket is a shallow groove on the tibia or shin of the hind leg, with hairs at the edges. In this the pollen is carried.

packet of pollen—red, yellow, or black—as the case may be. This they usually place in a cell of the comb, pressing it in with their head. As soon as this is done they are off again. Others come in with honey, made from the nectar of the flowers, which they regurgitate into the cells. As the bees pass into the hive, a guard approaches and often challenges them as it were. Meantime, the ventilating brigade is also busy, especially in times of heat, and it is said the in-draught will extinguish a candle held in front of the entrance on a hot night. When a bee or hatching-bee dies, or is dying, it is carried out to the tunnel. Many bees pass it without notice, like the Levite, but there is no good Samaritan; an active bee soon alights on it and carries it out with a swing over the board. There is no sentiment in a hive—work is its motto; and, when you can no longer work, the sentence is, "Out you go." The ghostly dead nymph is carried out in the bee's mandibles, as a dog carries a rabbit, and dropped over the edge of the landing board.

When summer is over, the bees huddle together on the upper and middle frames. The queen may still go on laying, but often she rests. The bees now require food, and can be seen with their little tongues licking up the syrup as it drops from the feeder, or busily gnawing the candy cake; and so they pass the time until spring comes, the monotony of their winter life being relieved sometimes by a brief outing in the frosty sun.

Work is more strenuous in the ordinary hive. There are ten frames in it, the stock may be very large, and the honey produced great in amount. In the observation hive, the bees get more sluggish as winter goes on, and the temperature falls from want of a sufficient number of bees to keep it up. Even if candy is given, they do not eat it, and ultimately the observer notes with sorrow that the cunning little workers, whose economy so interested him, are all dead before their time, and that in spring he must introduce a fresh stock to carry on the next year's work.

X

The Evolution of the Honey-Bee

(*Apis mellifica*)

and of Modern Bee Culture

"Wenn im Frühling die Alles belebende Sonne, den Boden bis zu einer gewissen Tiefe durchwarmt hat, so schlüpft aus einer selbstgegrabenen, meist an der Sonnenseite angelegten Höhle, aus einem morschen Baumstamm, aus einem Moosrasen oder einem andern Schlupfwinkel, wo es den Winterschlaf zugebracht, ein Hummelweibchen hervor." HOFFER.

X

The Evolution of the Honey-Bee

(*Apis mellifica*)

And of Modern Bee Culture

THE question may be here discussed as to how the honey-bee has reached such a high degree of specialisation. The answer of Evolution is, that it has done so by adaptation to external surroundings, and also from the power of variation in its germ-plasm.

The ancestors of the bees must have lived much as the humble-bee does now. Of this life Hoffer gives an interesting account in his work on the humble-bees of Styria, and Eimer and others have discussed the question.[21]

The mother humble-bee hibernates in her

retreat in the earth, or rotten tree trunk, and emerges in spring. She then builds her nest with a concealed opening facing the rising sun. After this, she lays eggs which produce workers—sterile females. She feeds the larvæ, flies out for food, until the young bees are born in May. The workers now take up duty like the honey-bee workers, and then the queen flies out less, and at last remains at home altogether. In July larger workers appear; these are the same in sex as the small workers but are not all sterile. The drones are produced, it is said, from the unfertilized eggs of the mother-bee and also from the eggs of both kinds of workers. At the end of the season the mother-bee lays queen-eggs.

In the nest at the end of the season there are therefore—(1) The mother-bee; (2) small workers, sterile females; (3) large workers, which may not be sterile but are less fertile than the queen, and may mate; (4) young perfect female bees — the future mothers. The final result is, that the young queens mate with drones in the open, the latter

dying on the autumn flowers from cold. The now mated queens each seek out a nest in which to hibernate till next spring, when the life already described begins again.

Hoffer records a picturesque feature in the humble-bee's life, namely, the existence of a trumpeter who between three and four a.m. hums so loudly, *r r—r r*, that the others are made aware that day is dawning and work must begin. This had been described two hundred years before by Gödart, in 1685, but discredited even by such a careful observer as Huber, and relegated, like the unfortunate Sprengel's work on cross-fertilisation by insects, to fable. Hoffer, however, observed it in a large colony of one species, *Bombus argillaceus* (*ruderatus*), he had placed in a box-nest, and had it verified by his wife and children whom he roused to hear it. He afterwards tells that, flinging sentiment to the winds, he seized the little knocker-up one morning, although he was stung *furchtbar*, one is glad to note, killed him, spitted him, "so dass er jetzt in meiner Sammlung paradirt." Next day, however, a small worker took up

the duty. Unfortunately, caterpillars whom Hoffer describes as "Die furchtbarsten Feinde der Hummeln" were too abundant in the hive and thus euthanasia by ether was the end of the interesting little colony.

It will be seen that in the humble-bee's life history, we have the rudiments of the more perfect and specialised life of the honey-bee. In the honey-bee, the queen-bee becomes a specialised egg-layer and does nothing else, only flying out for mating or to lead a swarm. The humble-bee drone does a little work and feeds himself; while the honey-bee drone restricts himself to a course of training as candidate for the post of the queen's consort. In the occasional honey-bee workers which lay eggs we see a reminiscence of the larger worker of the humble-bee.

The stages of the evolution of the honey-bee can only be surmised. A very fertile mother in the humble-bees would curtail her time of outside work, owing to the large brood of workers. The nest would increase in size, and thus accommodate the drones who might wish to stay on after nuptial time: this the

workers might resent; hence the massacre of the drones by the workers who would deal with them by snipping their wings.

All this does not explain many points. One must add to it the innate development of the germ-plasma. While the food given to larvæ may have an effect, *e.g.*, as to sex development, the reduction changes in the ovum taking place in the development of zygotes and gametes is probably the great factor; and in this we see that the career of the bee is determined by its germ-plasma and not merely by its environment. The bee in its race and life-history is really the "fly on the wheel of its fate," the germ-plasma.

The art of the apiarist has made great strides, and the method that has come down from long past ages, of rearing the bees in the many rude forms of hive, of which the straw-skep is best known to all of us, is a thing of the past and hardly even lingers in the out-of-the-way hamlet. In the straw-skep[a] the bees have full scope for their instincts. They first form the wax comb by hanging in clusters

[a] Now replaced by the modern box-hive.

motionless until, at a temperature in the cluster of about 85° F., little wax plates are formed and lie beneath the imbricated scales, on the lower surface of the abdomen. With these the comb is formed with its worker-and drone-cells and occasional queen-cells. The cause of the hexagonal shape of the cells is not cleared up. The cells are not round to begin with, and do not become hexagonal by mutual pressure. The hexagonal shape is said to give the cell the greatest capacity with a minimum of wax, and many pious ejaculations have been expended on this. Like the construction of the larger drone-cells, and the use of them by the queen-bee for drone-eggs only, it is as yet an unsolved problem, one of the mysteries of the creative power of the world, and we must at present accept it humbly, and not merely express our satisfaction with the ways of Providence, in the fulsome twaddle so much employed.

The apiarist, however, nowadays supplies the bee with a frame enclosing the wax foundation already described, and stamped with the outline and base of the cells, and this the bees

draw out so as to form the walls of the well-known cells. Unsuccessful attempts have been made to provide the drawn-out comb; so that, provided artificially with syrup, the worker-bee would simply need to stay at home, and, manufacturing its honey, pour it into the ready cells. Thus would the apiarist turn "sweater." There is little doubt this greedy honey-grabber would be ultimately disappointed by finding his plan unworkable. The plan of removing the full combs, extracting the honey by centrifugal action, and replacing the frames to be refilled, is however perfectly legitimate practice.

The presence of brood, *i.e.* of developing bees in the honey-comb, spoils it for sale, and thus an ingenious plan is usually adopted. On the top of the frames of the honey-combs is placed a queen-excluder, and above this the "sections," provided with a thin wax foundation, the well-known wooden frames in which honey is sold. The queen-excluder is a perforated zinc plate, the perforations being large enough to keep out the queen, but of a size to admit a worker. In this way the workers

pass in to fill the cells of the sections with honey, and to cap them, while no eggs can be laid in them by the queen. Some apiarists object to this and point out the undoubted fact that the top-combs are usually free from brood.

How to regulate or prevent swarming is a most important question. Swarming may be prevented when it is the mother-queen leading off a swarm, from an overcrowded hive. Here the apiarist, by removal of full frames and substitution of empty ones, by the uncapping of frames in the hive, *i.e.*, dexterously slicing off the caps of the cells so as to expose the honey for food, and by cutting out queen-cells, may induce the hive to go on with the mother-queen, *i.e.*, she will not swarm.

The swarm of the virgin-queen, however, cannot be prevented, as it is only in the open air that she can mate. The drone and queen do not mate in the hive, for reasons that need not be detailed. The apiarist can, however, supply a young fertile queen to the hive, removing an old one, and then, if the former is

received, no swarm for mating will occur. He may indeed clip the wings of the introduced fertile queen, and then she will never fly out.

This leads us now to one of the most astonishing advances in apiculture, namely, the artificial rearing of queens,[22] a plan chiefly due to Doolittle of America. What the apiarist may do is this. On a little block of wood he makes a short cylinder of wax, by dipping a piece of wood, rounded at its end and about the calibre of an ordinary lead pencil, into melted wax. These wax moulds he arranges on a half frame and places in a hive. Into the little cap of wax he now introduces a worker-egg of the third day and places in it a little royal food. The worker-bees accept this, complete the queen-cell, and a queen-bee is thus hatched. The vista this opens for future work is immense, and, although prosaic, is marvellous in its conception and carrying out.

To describe all the marvels of bee life—the scissors on the limb for snipping the wax plates, the spiracles for æration of the blood (scanty as the blood is), the nervous system,

the various secretions and their chemical action on food, the purposive life: all this would take volumes, and we can only say, Evolution, the Creator's mechanism, how marvellous are its works!

XI

Evolution and Controversy

"This slowness" (in remodelling our ideas) "ought not to dishearten us, for one of the strongest factors of social stability is the inertness, nay rather active hostility, with which human societies receive all new ideas. It is the crucible in which the dross is separated from the genuine metal, and which saves the body social from a succession of unprofitable and possibly injurious experimental variations. That the reformer should often be the martyr is, perhaps, a not over great price to pay for the caution with which as a whole Society must move; it may require years to replace a great leader of men, but a stable and efficient Society can only be the outcome of centuries of development."

KARL PEARSON, *Grammar of Science*, p. 1.

XI

Evolution and Controversy

It would appear at first sight that natural science should have less dispute as to its advances than philosophy or theology. Really it has not, as controversy is as bitter, prolonged, and unjust in science itself as in these sister subjects. Probably it has been more bitter in science, especially when theology and orthodox science have joined forces and added to ordinary controversy the bigotry and bitterness so often present in quasi-religious disputes.

In the history of the progress of Evolution we come first on the outpost skirmishes, and then on the battle-fields where serious war was waged and battles won or lost by the scientists. The occasional combats between Cuvier and St. Hilaire, between

Robert Chambers and those who really howled him down, were eclipsed after Darwin's great work, by the steady campaign that was organised against Darwinism. It cannot be otherwise. The progress of Truth is on the whole slow. It advances by leaps and bounds sometimes, but it very often, after a short advance, goes wrong from the want of balance of its votaries, their rashness in pushing theory too far, their haste in generalizing from too few data, or from their zeal, due sometimes to a feeling that the assertions in their works are not quite so true and accurate as they think, and that therefore emphasis is necessary. Earnestness is not knowledge, and thus the critics can step in and push their work aside for a time or for long.

We may pass over the controversy as to Chambers's *Vestiges of Creation* briefly. Of it we may now say that this work of a literary man was magnificent and astonishing, but it was not science. Probably no man's speculations have ever been more soundly abused or condemned by almost all the biologists of his

time, and it was really wise for him to have concealed his identity. Biology at that time was really a "contractor's depot," full of all kinds of material for construction, but in charge of it were many Giant Popes, who, as the result of an unthinking piety, forbade the use of any of it constructively. *That* was rash speculation, and so Biology droned on, so far as Evolution was concerned. Many of these men, however, like Cuvier and D'Orbigny and Owen, did magnificent work, and much of it is superior in power and illustration to that of the present day.

Darwin worked on true Baconian lines before Malthus' idea inspired him; for fifteen years he collected material before he began construction, and thus the attack on him was quite a different matter from that on Chambers, on whom the pious-minded could wreak their wrath unanswered. Darwin was the superior of most of them as to facts, and, although not combative, he had that weighty thought, calm and dispassionate mind, which after all is the most formidable factor in a controversy.

Darwinism had its friends, critics, and foes. Its friends were Henslow, Huxley, Lyell ultimately, and Hooker.[23] Its great critics—two in number, men worthy of that name—Fleeming-Jenkin and Mivart; its foes, an *omnium gatherum*, and in the majority, who, often with much knowledge of biology, had mingled with it a faith in swallowing the incomprehensible to a startling degree.

Huxley's powerful critical intellect, great knowledge, and trenchant style, really carried Darwinism on to victory. Yet he was no blind admirer, and early indicated the possibility of varieties and species being formed *per saltum*, a prophecy really which De Vries is establishing in his Mutation theory.

Mivart was and still is a formidable critic. Darwin believed in the accumulation of small accidental variations, acting with Natural Selection in producing species, but the argument of Mivart that "Natural Selection is incompetent to account for the incipient stage of useful structures," and for their preservation where they are not of utility and are therefore not preserved, is still of the greatest

importance. Mivart's whole literary and scientific outlook is valuable, and this is due to his grasp and breadth of philosophic and biological knowledge.

Fleeming-Jenkin, the versatile Professor of Engineering in the University of Edinburgh, in a review of Darwin's *Origin of Species* in the *North British Review* for 1867, suggested that the likelihood of single variations maintaining themselves in the struggle for existence was not great, and that they would be swamped. The fact of the transmission of the variation arising by the reductions in the gametes prior to fertilization and the transmission of such *variation* gametes, by their derivation from the variation zygote in its earliest stage, renders them more independent of environment than Darwin imagined. Environment only acts on the "soma," but the propagative part continues the strain, and, given a better environment, increase may be rapid.

The position the orthodox biologists took up seems now an extraordinary one. They accepted the account of the origin of the

world and of its inhabitants given in Genesis, as coming from the supreme wisdom and knowledge of the Creator, instead of its being a poetical account of it by the early Jewish race. One can reverently admire the biblical account of the Creation and rejoice in its beauty and poetry, and its freedom from all degrading legend, and yet disagree with those who would accept it as a final statement of what has happened. It is worthy of note that the view given by them and expounded by Mr. Gladstone, for instance, was not even that of St. Augustine, who, in the fourth century, held that God in the six days of Genesis created the potentialities of the world and of life, and not its actualities. It may indeed horrify them to be told that their supposed orthodoxy implies an adherence to the special theory of Suarez, the distinguished Jesuit (1548–1617). It must be noted, too, that Gladstone's power was based on his honesty, his emotion in the defence of the down-trodden, and his magnificent oratory, but that in scientific matters his intellect was undeveloped, and he could not understand

or appreciate Evolution. Evolution really involves the theory of a Creator whose power is expressed in it, and gives a conception of Him infinitely above that of average orthodoxy.

The foes of Evolution are too numerous even to mention, but we may select one as a type in Sedgwick, the Woodwardian Professor of Geology (1785–1866) and Prebendary of Norwich, a man held in the highest esteem by all his contemporaries. He had gone through the best university training of his day and proved himself a most capable student, coming out as Fifth Wrangler (1808) and ultimately Fellow of Trinity (1810). He was an eminent geologist and obtained the Copley Medal of the London Royal Society, an award . . . actively promoted by Professor Owen and carried against so distinguished a competitor as Mr. Darwin (Sedgwick's *Life*, vol. ii. p. 295).

Such a well-equipped investigator had no difficulty in overthrowing the *Vestiges of Creation*, and he did so in a manner that calls forth the remark from his distinguished

biographer that, "had the book . . . been ten times as ignorant and inaccurate as it was, it would be still impossible to defend the spirit in which he thought and wrote about it" (vol. ii. p. 82).

Darwin, however, was a different opponent. Sedgwick's letter to Darwin, who had sent him his Essay on the *Origin of Species*, is characteristic and full of interest. It is too long to quote, but the following extracts show the trend of his criticism sufficiently.

"I have read your book with more pain than pleasure. Parts of it I admired greatly, parts I laughed at till my sides were sore; other parts I read with absolute sorrow, because I think them utterly false and grievously mischievous . . ." Sedgwick had, however, the grace of humour, for he concludes with the following—"And now, to say a word about a son of a monkey and an old friend of yours, I am, etc.," and so on (vol. ii. pp. 356–358).

In a letter to Owen, we see Sedgwick in difficulties. "It is clear that there has been a law governing the succession of forms.

But here, by *law*, I mean order of succession,[a] and not a law like that of gravitation, out of which the actual movements of our system follow by mechanical succession. In that sense I do not believe in any law of creation. The highest point we can, I think, ever reach is a law of succession of forms, each implying a harmonious reference to an archetype, and each having indications of the action of a final cause, *i.e.*, of intelligent causation or creation. My belief is, first, that Darwin has deserted utterly the inductive track—the narrow but sure track of physical truth—and taken the broad way of hypothesis, which has led him (spite of his great knowledge) into great delusion; and made him the *advocate* instead of the *historian*—the teacher of Error instead of the apostle of Truth . . . a teacher of that which savours of rankest materialism in, and of an utter rejection of, the highest moral evidence and the highest moral truth. I must stop for want of room."

[a] Sedgwick would have been horrified if he had known that he was in this a disciple of Hume.

It would be unjust to criticise a private letter, in which Sedgwick lets himself go as any one may in such circumstances. The best sentence is the last, and the compliment to Owen in the allusion to the archetype is dexterous. Owen was really a very great observer, and had he not, against his judgment, rejected Evolution, might have taken a position near that of Darwin's (vol. ii. p. 360).

The whole letter is that of a good man struggling with difficulties. How a law can be merely an order of succession without causal interrelations, and why the mystery of gravitation should be so disparaged, it is difficult to say.

In a debate in the Cambridge Philosophical, where Sedgwick made a direct public attack on the *Origin of Species* we learn that although "Henslow defended Darwin . . . the general sense of the meeting was unquestionably . . . on Sedgwick's side." Sedgwick, still later, had to mourn the defection of the Geological from orthodoxy.

Sedgwick's life is fascinating, and is good

reading. It contains some excellent dog stories which must have delighted the *Spectator* of the day. It is of special interest as showing how Evolution affected a powerful but narrow intellect, and that in controversy most men don't think but take the "broad way" of following. The charge of Materialism is absurd, but the view of the Creator as anthropomorphic, benevolent on the whole, and interfering certainly, was then at its strongest.

Let us not think, however, that we are at present above the mistakes of the anti-evolutionists of the nineteenth century. The present generation has its rivalries and bitternesses, and it is not a question of a war between special creation and Darwinism, but of one in which Darwinians, Neo-Lamarckians, Weismannites, Biometricians, Mendelians, Mnemists, and Mutationists are inextricably mixed as yet. But on this fight it will be best at present to look on cynically and whisper to oneself, "Non nostrum est tantas componere lites."

If, then, philosophers and theologians and scientists fight for their little gods,

surely the perplexed reader may urge—one will not find such rivalries where human life and safety are concerned. Alas, it is worse, my simple querist, as I must now briefly tell you.

At one time the scourge of the Lying-in-Hospital was blood-poisoning to the mother. A great investigator, Semmelweiss, showed, in 1843, how this could be avoided. The success of the discovery was his destruction. The men immediately concerned in the spread of the doctrine of safety, not only ignored it, but hunted Semmelweiss from Vienna. No wonder he ultimately went mad. Now, there is a great monument to him in Budapest, and let us hope he can look down and see what has been done for him fifty years after his untimely death. Much might be shown in the same strain as to Listerism, but enough has been said on this unfortunate point.

What, then, are we to think of all this? It is really inevitable. The man of genius is a prophet, a seer, who can look ahead over the undiscovered land and see the hills

of the Land of Promise, while the critic is peering for the footpath. Many able men can describe accurately the apples in the dumpling, but cannot conceive, any more than George III (of great and good memory), how they got inside: and so the fight goes on, the seer eagerly pointing to the Horizon of Hope, the critic savagely demonstrating the actual unexplored morasses in front. The seer may take all this sadly and may be temporarily eclipsed, like Mendel; or, like Lister, he may ignore it and ride calmly and carelessly o'er the plain. The day comes, however, when the controversy is threshed out, the morasses have been drained and explored, the roads made, and the aftercomers can sun themselves on the hills so hardly won, grateful to the guides who have made the path and perhaps lost reputation and life in doing so.

XII

The Handicap of Sex

"Das Ewig-weibliche zieht uns heran."

GOETHE.

"Wenn müde mich in froher Kinderzeit
Zu Bett am Abend meine Mutter brachte,
Dann sass gebeugt sie auf die Naharbeit
Noch lang bei mir und wachte,
Sie sang dabei ein süsses kleines Lied,
Das klang so hold wie eine Feenweise,
Erinn'rung dran noch immer lindernd zieht,
Mir durch die Seele leise,
Die Tone schwinden sanft im stillen Raum,
Als ob vor Innigkeit sie beben müssen,
Sie schweben durch das Dunkel wie ein Traum.
Leicht wie ein Hauch von Küssen."

ADA NEGRIS.

"Die Frauen haben ja in allen Zweigen der Kunst und des Wissens, von den altesten Zeiten bis zur heutigen Stunde hochst Ehrenvolles und Anerkennenswertes geleistet, aber bis zu dem Niveau welches die Männer erreichten, haben sie sich nicht erhoben, das ist in der natürlichen Organisation des Weibes tief gewurzelt." WALDEYER.

XII

The Handicap of Sex

In the human race sex has differentiated, that is, the gametes necessary to provide progeny are derived from two individuals. It is more correct to say, that sex has incompletely differentiated where separate sexes exist, as curiously enough, in mammals the female has degenerated traces of male organs, and the male corresponding degenerated traces of female organs, both in a definite but fragmentary and less developed state. This fact is of profound significance, and shows among other things that this differentiation has taken place most probably from a past ancestor, far away back, from invertebrate hermaphrodites, and that the sexes have become separated to establish variation. In mammalian reproduction the

gametes, as we have seen, first lose certain elements, and thus changed, vary or cross just as tall and dwarf peas do.

By such differentiation we have now, in the human race, man and woman, male and female, differing but alike; and one of their great functions is, by gametic combination, to carry on the torch of life.

One of the most important questions of the day is that of the essential capabilities of woman and man. Has man a superiority for effective work in this world over a woman? Is she handicapped in this work by what her supreme function of motherhood demands? Must, in this world's life, man lead, in the main, and woman follow? To consider this we now go on to discuss what are the essential differences, if any, between the sexes.

Statistics of birth show that more boys are born than girls; and Morgan's[a] summary gives this well. Thus European records derived from millions of births show that 106 male children are born to 100 females.

[a] Morgan, T. H., *Experimental Zoology*, p. 365, 1907.

In adult life, however, the figures are different, *i.e.*, we get 1024 women to every 1000 men. It seems to come about in this way. At puberty the numbers are nearly equal, showing that there has been a higher mortality in males; after thirty-five, the death-rate is higher in men, and the final result of more women than men is attained.

It is this excess, then, of women in the civilized world and the non-marriage of many, that are the greatest factors in bringing forward the clamant question of their up-bringing and employment.

Up till fourteen or fifteen years of age, boys and girls are much alike, equally active and combative, equals in games and fun; but at this period of life a distinct and unconscious change begins. The boy remains thin, but more aggressive in his proceedings, is the delighted anxiety of his feminine relatives, and full of an inquiring mischievousness, which makes him often the *bête noire* of those who cannot view his escapades through the rose-coloured spectacles of the mother. He is then usually averse to formal

instruction, which he terms "rot," and displays great contempt for his sisters and their school friends, who often easily surpass him in his tasks. He believes in football and "tuck," and his natural religion is pagan. When approaching manhood, however, he begins to draw up in the race, sees the responsibilities facing him, and easily overtakes and keeps ahead of his once formidable feminine opponents. His feelings towards women undergo a change; he is eager to please them, and may lament his blushing gawkiness towards some damsel—now a goddess from afar—whom not so long ago he had mercilessly chased or despised in her sports. Henceforth he can lead in effective work—"an honest man, the noblest work of God."

On the other hand, the girl at this age increases in weight and becomes plump and not so lanky as the boy, although the *Backfisch* or *flapper* is often with us as in Germany. She becomes more reticent and shy, eager at her school work, often toiling far beyond her strength. It is here

that many girls suffer and become bloodless, and it would be much better were they less pushed at this time and encouraged to follow the example of their unconsciously more sensible brothers. After seventeen, the girl usually slackens her efforts after knowledge, and devotes more of her attention to adornment or even to coquetry. At any rate, the boy's superior physical strength and more robust nervous system give him a staying power she does not possess.

The adult man and woman thus differ in their capabilities and yet are complementary in these. How far is this exact? Much has been written and debated on this subject, but in no work I have read is it more thoroughly or judiciously considered than in a recent book by Emeritus Professor von Winckel of Munich who, after a long and distinguished career of professional activity as an obstetrician and gynæcologist, has recently given us the benefits of his ripe experience and knowledge on the position of women in the race and in the world. His opinion is given dispassionately, but is on the whole in

favour of the contention of those who hold to the near equality of the mental powers of the sexes. If this equality has not been attained at present, there is good hope of its being attainable in the future under more favourable circumstances. "Die These von der geistigen Inferiorität des Weibes fängt also an, etwas zweifelhaft zu werden, und wenn Sie M. H. einmal in Ihrer späteren Laufbahn in Konkurrenz mit Frauen auf geistigem Gebiete zu treten gezwungen sind, so unterschätzen und verachten Sie deren Leistungen nicht, es könnte Ihr Schaden sein, sondern suchen Sie dieselben nur durch bessere Leistungen zu übertreffen!"

At birth, boys are larger and heavier than girls, and this is true of them as adults. The figure of a woman differs from that of a man, being plumper, less angular, with a fuller bust and broader hips. The angle which the lower limbs make with the trunk is less in woman, and thus their gait, when the hip-breadth is well-marked, is less graceful, and may even, in pronounced cases, become almost waddling. The trunk in women is also re-

latively longer, as to the limbs than in man. These are the most pronounced differences, but there are many minor ones we need not mention.

The most important question is, however, that of brain differences. Here no distinct anatomical opinion can be given. Relatively to the rest of the body, the weight of the brain in woman is greater than that of man ($\frac{1}{36} : \frac{1}{36}$). While the average weight of the brain in man is greater than in woman (by 134 grammes), it must be kept in mind that the convolutions of the grey substance may mean more than mere weight, and that increased weight of the brain is one thing and that of the grey substance quite another. The opinions on this subject have varied, and the general conclusion at present is, that in the sexes the brain capability of women more nearly approaches that of men than the lord of creation fondly imagines.

We are on surer ground, however, when we consider functional differences. Women are more eager and intuitive than men: they come to conclusions more rapidly and

weigh the results of their thought less. *Fiat justitia* seems to them so strong that the *ruat coelum* is not considered enough. Men would endeavour to avoid the latter by a compromise, but, for women, that is anathema. They would push on logically, and then adjure men to clear away the celestial debris and free them.

In art, science, politics,[a] women have not taken the position men have. If we make a first class in all these branches, there will be no woman in it. No woman can be placed on a level with Shakespeare, Scott, Goethe, Victor Hugo, Thackeray, Balzac, Tolstoy, Raphael, Michael Angelo, Millet, Turner, Beethoven. Mrs. Browning, Charlotte Brontë, George Eliot, George Sand, Rosa Bonheur, are not among these gods of Art, and some of the former have no rivals in women by any means. Can this be changed? Will, in the future, super-woman overtop man?

In considering this we must keep in mind

[a] It is remarkable that in philosophy, women have not even scintillated, far less shone.

two things, namely, woman's staying power, and how far her mental capabilities are modified by her sex. Woman can certainly do what man does in ordinary life, but how far she can go on doing so without damage to her nervous system or her sex-characteristics, is quite another matter. Certainly, she will suffer more than a robust male and more even than the neurotic man.

In some work, woman is far ahead of man. She has in some respects a more tolerant nervous system than man. Her passive resistance is greater. This is brought out in her great gift of nursing, where she stands supreme, and outclasses the average male nurse completely. Her insight into a child's or invalid's wants and needs is extraordinary. She is a much better patient than a man, and bears operative procedure better. Billroth, the great Vienna surgeon, tried some of his then daring operations on women first; they were better subjects than men, and recovered better.

Woman is thus splendidly modified by nature for motherhood and to a certain

extent disqualified in other aspects of the life struggle. She has more of her life taken up in her special functions, and is indeed, often enough, temporarily laid aside for their fulfilment. At puberty, when, if the views of extreme feminine publicists were taken, she should develop as the boy does, nature cynically begins to modify her for her future place in life. The girl responds to it unconsciously, and at reception and ball, at the proper time, displays her charms, just as her sister in the Stone Age probably revealed what led our rude forefathers to admire her, and in their own rough yet gallant way, to club her and drag her off to their future home.

It is really in motherhood that nature is justified. Here the woman is all grace and power—is worshippable; a man appreciates a baby, but in his exhibition of this is too often *gauche* and ridiculous. The power of motherhood is not lost by higher education, and too often and too soon the woman who has shone in the tripos or in the medical class-room, yields to its prospects and attempts

courageously to combine the two most exacting occupations in the world, medicine and maternity.

At this very hour, the question of the franchise for women has emerged from prominence into notoriety. That women are determined to have the vote is undoubted; that politicians are postponing the possible *ruat coelum* is equally evident. In the present contest, certain of the feminine combatants are showing the strength and the weakness of their sex. The kingdom of politics is not to be won by corybantic display, or by processions headed by daring leaders astride led horses, or by disturbing a jaded politician at dinner—an aggravation of the serious offence of *Hamesucken* in old Scots law. Such exhibitions give the male Philistine sport for ungainly ridicule. The vote may come, but it will not be rushed, and, when it is obtained, let us hope it will not have the history of a mere feminine fashion—eagerly accepted, spasmodically exercised, and finally tossed aside for a fresh excitement.

The sum of the whole matter, then, may

be put thus: Man and woman are equipotential but not equivalent. The differentiation of sex has handicapped woman more than man; yet for all that she has the greatest influence on man, and at one stage of his primitive career turned the development of the race heavenwards and formed the most sacred thing in the world—Home and Hearth.

Nature has made woman's life one of special sacrifice, and has so tightened the bonds for this purpose, that the attempt to break them and lead what some feminine leaders ingenuously believe to be the higher life of a man, can only end in that most dreadful of catastrophes—Nature's Revenge.

XIII

Evolution in Religion

"It is especially the interpretation of the Bible and of the history of the Church which has shown the danger of the doctrinaire attitude and of doctrinal immobility, and which has brought to a point the conflict between science and religion, or rather between science and theologism. Catholics and Protestants alike, for centuries, have bound up their faith with a literal interpretation of Scripture." DR. SAROLEA'S *Newman*, p. 158.

"William Robertson Smith had the passion of the lover for Truth. You could see it in that pale face with its sensitive, indeed petulant, mouth, and its large, bright, eager eyes. And he assumed that his Church shared that love."

DR. P. CARNEGIE SIMPSON,
Life of Principal Rainy, vol. i. p. 314.

"To me the universe was all void of life, of purpose, of volition, even of hostility; it was one huge, dead, immeasurable steam-engine, rolling on in its dead indifference, to grind me limb from limb. Oh the vast, gloomy, solitary Golgotha and mill of death! . . . Full of such humour was I one sultry dog-day, after much perambulation toiling along the dirty little Rue St. Thomas de l'Enfer in a close atmosphere and over pavements hot as Nebuchadnezzar's furnace; whereby doubtless my spirits were little cheered; when all at once there rose a thought in me, and I asked myself, 'What art thou afraid of? wherefore like a coward dost thou for ever pip and whimper, and go cowering and trembling? Despicable biped! what is the sum total of the worst that lies before thee? Death? Well, death; and say the pangs of Tophet too, and all that the devil and man may, will, or can do against thee! Hast thou not a heart? canst thou not suffer whatsoever it be; and, as a child of freedom, though outcast, trample Tophet itself under thy feet, while it consumes thee? Let it come, then, and I will meet it and defy it.' And as I so thought, there rushed like a stream of fire over my whole soul, and I shook base fear away from me for ever. I was strong; of unknown strength; a spirit; almost a god. Ever from that time, the temper of my misery was changed; not fear or whining sorrow was it, but indignation and grim, fire-eyed defiance."

Carlyle's Early Life, vol. i. p. 107.

XIII

Evolution in Religion

CURRENT orthodox views as to Christianity stand, at present, much at the same stage as those of biologists in regard to the origin of species, prior to Darwin's work. Species were then considered by biologists as having been created within the six days of Genesis; they were distinctly differentiated, did not evolve from previous forms; and the most extreme upholders of this view held that no new species had been created after the date fixed by Usher's chronology. Cuvier even accounted for fossil extinct forms by great geological catastrophes, but did not hold any doctrine of renewed special creation.

The *Essays*, edited by Seward and published as a memorial of the centenary of Darwin's birth, have shown the striking fact,

that Evolution acts in all that affects man, and that it is the great law with which, among others, all investigators must work. This thus raises the question, How does Evolution affect our view of the Bible? How does it influence one's views as to the origin of religious belief?

The Bible and Christianity have been assailed by many, and the attacks have been made on the view of them, unfortunately granted by the orthodox, that Christianity is a direct Divine revelation to man, and that the Bible contains the supreme wisdom of the Creator, and not a history of the slow evolution of religious belief, in a specially monotheistic nation. Sometimes the attack is made, as in Nietzsche's case, not on Christianity, but on a caricature of it, set up to afford sport to the Hedonists.

If we take the view that the Bible is the history of the development of religion in the Hebrew race, then much that is urged against it fails to convince any dispassionate mind. Huxley has pointed out the evolution in the idea of God in the Bible, from the

anthropomorphic one, when He spake as a glorified man to Moses, up to the higher and loftier views expressed in the Psalms and Prophets. We see here a spiritualization of the religious ideas of the Creator, from mere anthropomorphism on to reverence and awe. The idea of God is revealed through man and recorded in Scripture.

The morality of the religious leaders as revealed in the Old Testament, the religious fanaticism, often going on to savagery, animating them in their wars, are all evidence of the same fact; we see man evolving his religious belief according to his stage of development. Religious belief, in its present form of Christianity, has evolved from the lower forms, so interesting to all students, and well illustrated in the books of Judges and Samuel. Huxley's essay on "The Evolution of Theology" [a] is well worthy of study on this point. While the Bible is the great guide for the conduct of nations, and Christianity undoubtedly the most perfect form of religion, it must be admitted that some of the

[a] *Collected Essays*, iv. 285.

early legends recorded in the Bible have done great harm to mankind. The legend of the Fall has undoubtedly entailed on women a crippled career in this world, from which they have not yet emerged, and given rise to the view so widely held of their inferiority to man. That this is no imaginary grievance is shown by the fact, that when the use of chloroform in labour was introduced by the famous obstetrician, Sir James Simpson, there were those who actually held that it should be withheld from them at the time of their necessity. Had it not been written, "In sorrow shalt thou bring forth." Simpson had specially to combat such objections and, rejoicing in controversy as was his wont, he had no difficulty in disposing of their arguments. Probably he would have done better to have turned the objectors over to the injured matrons themselves.

"Cursed be Canaan" is another instance of such harm, and the saying, "Thou shalt not suffer a witch" (really a poisoner) "to live," has been the cause of untold torture to the defenceless in this matter. There is no

irreverence, no irreligion in these remarks. The biblical records on these points must be read as historical records of religious and ethical development, as the record of man's opinions at a certain stage of his development, and not as the supreme wisdom of the Creator, and therefore all binding on man in subsequent generations.

It may be urged that such a view excludes belief in God. Such an objection is quite futile. There is in it the fallacy that the Creator can reveal Himself to man only by direct and completed acts, and not in a slow development of the human powers. These powers and their innate tendency towards a higher religious and ethical standpoint are none the less implanted in him by the Creator. Evolutionists see, in the history of the world and of man, divine power, and have a higher conception of its greatness and mystery than the direct creationist can possess.

We get further light on many points from Evolution. Buddhism and Confucianism owe their type to the nature of the race in

which they have developed, and this must be borne in mind in studying them. They are not degenerate religions, but religious beliefs developing under special mental powers and limitations. A race gets the religion it evolves and deserves.

It is often debated by the anxious mind of man, How sin came into the world? Evolution gives the best answer. Sin is the action of the undesirable qualities existing in man, as the result of his development. In sin, we see the heritage of the man of the Stone Age, in whom lust and greed and selfishness reigned supreme, almost as a necessity of his existence; while charity and generosity and altruism were rudimentary. Yet in him there was implanted a rudimentary divinity, and gradually, as ages went on, it began to tell; and now it is in man, side by side with his baser self. The natural man of the theologian is still reminiscent of his ancestor of the Stone Age, and in some its influence is nearly supreme. To that wilful survivor of primitive man, there will be allotted the results of his mad rejection of the divine

monitor in him, and he will, in his lifetime certainly reap the harvest that sin, the destroyer of the divine and of the material in man, gives to all who dwell on the Venusberg or wallow in the train of Bacchus and his satyrs. There is thus a great law in Man's history, "warring against the flesh,"—the law of spiritualization, and if in its light we view our religion, our virtues and our sins, we see, "through a glass darkly," that "God has not left man without a witness," but has also given him light and leading and faith in the supreme Saviour of the World.

Evolution teaches charity in judgment. It regards early religions as containing the promise of higher ones, and sees the occasional disaster of their too enthusiastic enforcement of the latter as that of "new wine in old bottles."

The greatest lesson of Evolution is Hope. Man has risen, not fallen, and is rising. He inherits the passions of the past, but has in him the Divine spark that can be fanned into a steady flame. No doubt the view of his utter vileness may appear to prevent pre-

sumption, but it is an insult to his Maker in whose image he has been created.

There is, therefore, hope for the future of man in this life; he will not, we trust, be the *Ueber-Mensch* of Nietzsche, that compound of Bismarck and Machiavelli—who is to trample under foot those whom he deems the weak of the earth; but the truly great man, strong in help, strong in resisting the power to crush; he who will, like his Master, show his strength in that "the bruised reed he will not break, the smoking flax he will not quench."

XIV

Men who have Revealed Themselves

"Upon one of these fruits of the tree of nascent experience (evil) men usually keep strict silence. Rousseau is the only person that ever lived who proclaimed to the whole world, as a part of his own biography, the ignoble circumstances of the birth of sensuality in boyhood." MORLEY'S *Rousseau*, vol. i. p. 15.

Those who wait at the bedside of the dying tell, that at the last, when the Angel of Death seems ready to strike the fatal blow, he affects to pause, and even to sheathe his sword; but only the inexperienced watcher thinks that he is about to spread his wings and depart. It is really a respite and not a reprieve. It is then that to the dying man there come a renewal of strength and a clarity of thought widely different from his previous apathy. Through his brain cells, from some long disused records, there come surging up (like the post-haste messenger of some Eastern potentate, his horse's sides reeking and bleeding), the characteristic ambition, the repeated life-impress, or perhaps the long-forgotten and shameful life episode. So Napoleon muttered, "Tête d'armée"; good old Dr. Adam of the Edinburgh High School, "It is dark now, boys, you may go"; while the poor European waif, dying the drunkard's death with his weeping native wife faithful at his side, sat up erect, "Not guilty, my Lord!"

XIV

Men who have Revealed Themselves

THE most common and characteristic trait of mankind is personal reticence. The grave receives humanity with the record of all its secrets and weaknesses hidden from the public scrutiny, so that beneath the most commonplace and mendacious epitaph there may lie secrets at which, if revealed, the world would stare—*dies declaret.*

It is a commonplace that the author reveals in his work, if not himself, at any rate his life experience. How much is self-revelation is the mystery, and peeping Tom often tries to find this out, especially where the scanty records of the author's life prompt him to give rein to what he is pleased to consider his imagination, but what is merely

an exaggeration of that fault for which he was righteously flogged at school. Thus the great author's verse is forced or even tortured to prove him a hero or a dastard or a sensualist, and without scruple the incidents of his play or poem are made to fit some preconceived rigid theory.

Shakespeare's memory has been the most afflicted of all. The events of his life known to us are, on the whole, scanty, but his life has been reconstructed for us, and if we are impressionable and non-critical we can almost see him live before us in Stratford and London. He is the crawling school-boy, the too ardent lover, the poacher, the needy player and playwright, the rich shareholder of the Globe, the obsequious hanger-on of lords, the sensual man-about-town, fluttering like the moth round the fascinating and wicked Mary Fitton; finally, the man who rusted out his life in a country village and ended it in a drunken debauch. The man who studies his Shakespeare will wisely smile at much of this, and divide literary mankind into Shakespeare and the rest—the one a little lower than the

angels, and the others, who must sit, *longo intervallo*, at his feet in their proper degree of approach. Shakespeare's life has been guessed at with the spiritual insight of Dowden and of Bradley; the brush of Brandes has painted it in roseate hues, and the pessimistic pen of Mr. Harris has followed the lead of Henley on Burns. Mr. Harris has shown learning and industry, and his work gives much room for thought. That Mary Fitton affected Shakespeare's life too much, we deny. His portrait of her is not that of a sensual man viewing a Salome.

"My mistress' eyes are nothing like the sun;
Coral is far more red than her lips red:
If snow be white, why then her breasts are dun;
If hairs be wires, black wires grow on her head.
I have seen roses damask'd red and white,
But no such roses see I in her cheek;
And in some perfumes is there more delight
Than in the breath that from my mistress reeks.
I love to hear her speak, yet well I know
That music hath a far more pleasing sound:
I grant I never saw a goddess go,
My mistress when she walks treads on the ground.
And yet, by Heaven, I think my love as rare
As any she belied with false compare."

This is not the appraisement of the sensual man but of dispassionate infatuation. Mary

Fitton was a wanton, a winebibber, a lover of flattery, one who could give and take in wit. That Shakespeare fell with her we deplore, but his degradation in this has been the world's gain, and if Shakespeare had been guided by a maiden aunt, mankind would have lost much of the immortal in literature. Let us not forget his repentance—

> "What potions have I not drunk of Siren tears
> distilled from limbecks foul as Hell."

We are not concerned, however, specially here with this line of thought; not with those who have merely unlocked their hearts, but with those who have done so and inventoried the contents, even to the dregs. Such men are few—only three great ones, Rousseau, Pepys, and Amiel. To them has been granted more than the prayer, "Ah! Seigneur, donnez-moi la force et le courage de contempler mon cœur et mon corps sans dégoût": the power to look in and to reveal to the world.

When we know an author's life, we find that his skeleton, as a rule, is not depicted in his fiction or drama. Scott gave no hint

of his family ambition and real financial speculation even in his diary; it is by Charlotte Brontë and not by Thackeray that the calamity of the insane wife is drawn: while Dickens, though he drew his father in Micawber and in many scenes of *David Copperfield* gave us phases of his own actual life-experiences, did not depict any episodes giving us the secret of his marred domestic life.

It is different with the three we have mentioned. Each of them dipped his pen in the real, and wrote it boldly, unmindful whether it showed him up in a favourable, unfavourable, or even in a despicable aspect. They detached themselves from themselves, and observed and recorded their own virtues and vices as coolly and dispassionately as a sphygmograph does the pulse. The results displayed are to them merely the surge and the ebb of passion or infatuation, and in the nature of things.

Rousseau in his *Confessions* is not discussable. There is no antiseptic in which one could dip one's pen even to allude to

his mawkish sensuality. Yet we must not blind ourselves to his genius and his power as a force with mankind. *That* one can see in Morley's pages; and Amiel, the pure-minded, rightly wrote of him as "an ancestor in all things, . . . nobody has had more influence than he upon the French Revolution, for he was the demi-god of it and stands between Necker and Napoleon. He came into collision with his time; hence his eloquence and misfortunes. Nobody, again, has had more than he upon the nineteenth century, for Byron, Chateaubriand, Madame de Staël, and George Sand all descend from him."[a]

With Pepys we are in a higher atmosphere, not a moral one certainly, but Pepys was a sturdier, cleaner sinner than Rousseau, if one dare say so: we deplore his lapses, but he does not disgust us, as Rousseau does, with his chaste tears and his unchaste acts.

When the garrulous Pepys wrote his *Diary*, he drew an accurate picture of himself and his time. We see him under all

[a] Amiel's *Journal*, vol. i. p. 202.

aspects, and can imagine him fussy and yet precise in business matters. We smile at his generous allowance for his own dress, and his niggardliness to his pretty young wife—poor wretch, as he affectionately terms her. This contradiction runs through all his life record He writes down his nefarious intentions on Deb's honour, and yet can record of his Royal master, the debauchee, Charles II :

"After dinner I went up to Sir Thomas Crewe, and then I sat talking with him the whole afternoon upon the unhappy posture of things at this time; that the King do mind nothing but pleasures, and hates the very sight or thought of business; that my Lady Castlemaine rules him, who he says has all the tricks of Aretin. If any of the sober councillors give him good advice and move him in anything that is to his good and honour, the other part, which are his councillors of pleasure, take him when he is with my Lady Castlemaine and in a humour of delight, and then persuade him that he ought not to hear nor listen

to the advice of those old dotards or councillors that were forthwith his enemies; when, God knows! it is they that do most study his honour."[a]

Pepys was a patriot and an honourable man of business, and never condones the King's errors but censures them devoutly. He was a lover of book bindings, not of their contents, and this he makes clear: "To a bookseller's and bought, for the love of binding, three books—the French *Psalms* in four parts, Bacon's *Organon*, and *Fornab. Rhetor*"—a good literary selection, but for it Pepys takes no credit. He was a lover of the theatre, but the plays that amused him "mightily" are strange to modern ears. Shakespeare had little attraction for him, although he admired *Macbeth* and *Hamlet*; but *Midsummer Night's Dream* he records as "the most insipid ridiculous play I ever saw in my life." Although a regular churchgoer his remarks are not edifying and usually worldly, but the mystic 666 seems to have fascinated him. At the last, poor Pepys

[a] Globe Edition, p. 195.

himself dispassionately records the Nemesis that overtook him for his many lapses from conjugal fidelity. "This evening I perceived my wife mighty dull, and I myself was not mighty fond because of some hard words she did give me at noon, out of a jealousy at my being abroad this morning, which, God knows, it was upon the business of the office unexpectedly; but I to bed, not thinking but she would come after me. But waking, by and by, out of a slumber, which I usually fall into presently after my coming into the bed, I found she did not prepare to come to bed, but got fresh candles and more wood for her fire, it being mighty cold too. At this, being troubled, I after a while prayed her to come to bed, so after an hour or two, she, silent, and I now and then praying her to come to bed, she fell out into a fury, that I was a rogue and false to her. I did, as I might truly, deny it, and was mightily troubled, but all would not serve. At last, about one o'clock, she came to my side of the bed and drew my curtain open, and with the tongs red hot at the ends, made

as if she designed to pinch me with them, at which, in dismay, I rose up, and with a few words she laid them down; and did by little and little, very sillily, let all the discourse fall; and about two, came to bed and there lay well all night, and long in talking together, with much pleasure, it being, I know, nothing but her doubt about my going out yesterday, without telling her of my going, which did vex her, poor wretch! last night, and I cannot blame her jealousy, though it do vex me to the heart.[a]

Pepys' *Diary* is a human and honest document, and every reader loves him even in his prolix narration of his daily routine work, of his foibles and vanities. His description of his anxieties in his official work must appeal to all. He had to clear his department before the House of Commons for maladministration, and in a three hours' speech convinced all his hearers as to his rectitude. On this turning-point in his official career he says: "Vexed and sickish to bed, and there slept about three hours,

[a] *Op. cit.*, p. 206.

and then waked, and never in so much trouble, in all my life, of mind, thinking of the task I have upon me and upon what dissatisfactory grounds, and what the issue of it may be. . . . With these thoughts I lay troubling myself till six o'clock, restless, and at last getting my wife to talk to me to comfort me, which she at last did, and made me resolve to quit my hands of this office and endure the trouble no longer than I can clear myself of it. So with great trouble, but yet with some ease from the discourse of my wife, I up, and at my office."

Pepys, in wig and brocade, looks out on us complacently, if a little anxiously, in his portrait, and no one would imagine from it that in his life there had been the comedy and tragedy, the *Sturm und Drang*, his *Diary* records. Historian and reader are grateful to Pepys for the many hours he spent with his life-record.

Amiel's *Life and Record* is a most fascinating one, and the reader will find in M. Scherer's *Fragments d'un Journal intime* and in Mrs. Humphry Ward's sympathetic

biography of him, and her translation of his *Journal intime*, both entrancement and profit. That there should have been a man who as a teacher was a pedant and a failure; as a private diarist, a most brilliant writer, penetrating critic, and deep philosopher; one who was a distinctly minor poet in his published work and yet a master of prose in writing what at first he never meant to publish, and wrote only for his own satisfaction; one who could not summon up courage to make the plunge into the literary world during life, and yet, by his sanction of the publication of his *Journal* after death, has taken his place among the immortals of literature—all this seems paradoxical if not untrue; yet it happened and can be studied psychologically.

Henri Frédéric Amiel was born at Geneva in 1821, of Huguenot parents. He was left an orphan in his twelfth year, and was brought up by a relative. He was, however, in circumstances that enabled him to take a university training, to travel extensively in Europe, and to study for four

years in Berlin. At the age of twenty-eight the determining point in his career happened. He was appointed, by competitive examination, Professor of Æsthetics and French Literature in the Academy of Geneva. One thinks of that as a *point d'appui* from which he would make a steady rise in the literary and philosophical world. Unfortunately, political strife was intermingled with his appointment, and Amiel found himself ignored and probably misrepresented by the conservative university party. He was thus caught in that most virulent of all environments—a hostile narrow university one—and to a man of his sensitive and proud nature the result was fatal. In public he shrank into himself, and as a teacher practically repressed his originality and freshness of outlook on literature and philosophy, and developed into the narrow pedant who gave his students a skeleton course, accurate but without living flesh. He inspired none of his hearers, and as a teacher was considered a failure. The natural result of this was a morbid self-depreciation of his own abilities,

and a desire to get through his daily work officially and be done with it. Finally, this led to an irresolution as to the execution of general literary work, and a shrinking from all responsibility in regard to it. Had he had the determination to reveal himself, careless of what anyone thought—to yield, in fact, to the inspiration of his genius, he might have rehabilitated his reputation, won his own self-respect and established himself in his own lifetime as a great thinker.

We must not forget, however, that his environment was not altogether to blame. He had in him the peculiar temperament of self-reflection, a contentment with his own thought, a self-absorption and delight in the inward consciousness of truth and beauty, and an almost trance-like delight in pure mental reflection. Like opium, his thought intoxicated him, and he seems to have been able to pass into an intellectual Nirvana, conscious and yet cut off from actual surroundings. He himself recognises his Buddhistic failing, and says: "The Buddhist tendency in me blinds the faculty

of a free self-government, and weakens the power of free action; self-distrust kills all desire and reduces me again and again to a fundamental scepticism" (vol. i. p. 226).

Now comes the astonishing feature in his life. Just as Pepys sat down night after night to write, in his crabbed shorthand, his immortal *Diary*, so Amiel in his quiet study, when the world was at rest and in darkness, wrote up his *Journal intime*, and there analysed his own powers and mental failings, discussed religious and philosophical problems in the frankest and most trenchant manner, and in a style limpid, clear, free from all obscurity. There was no responsibility in this; he felt sure no mortal would ever see these confessions of a soul, and thus his genius was unrestrained, and used its powers to its utmost. That he afterwards modified his original intention and suggested the posthumous publication of his *Journal* in part, makes no difference in the astonishing fact just recorded. In the evening of his life, he felt that his career had seemed a failure, but recognising his own powers,

the inspiration of publication came to him, and thus it is that mankind is the happy possessor of the thoughts of one of the greatest and purest of self-revealers.

The *Journal* lends itself to quotation, but this must be brief and therefore inadequate. Some paragraphs, however, may show its richness and suggestiveness, and set, we hope, many readers to its perusal.

One of the first difficulties of the young philosophical student is the check put to apparent knowledge, when he is told we must limit our apparently rational ideas of what lies outside us, to our sense perceptions. On this Amiel is delightfully clear:

"We have had a philosophical meeting at the house of Edouard Claparède. The question of the order of the day was the nature of sensation. Claparède pronounced for the absolute subjectivity of our experience—in other words, for pure idealism —which is amusing from a naturalist. According to him the *ego* alone exists, and the universe is but a projection from the *ego*, a phantasmagoria which we create ourselves

without suspecting it, believing all the time that we ourselves are lookers-on. It is our *noumenon* which objectifies itself as *phenomenon.* The *ego* according to him is a radiating force which, modified without knowing what it is that modifies it, imagines it, by virtue of the principle of causality—that is to say, produces the great illusion of the objective world in order so to explain itself; our waking life, therefore, is but a more connected dream. The self is unknown which gives birth to an infinite number of unknowns by a fatality of its nature—science is summed up in the consciousness that nothing exists but consciousness. In other words, the intelligent issues from the unintelligible, in order to return to it, or rather the *ego* explains itself by the *non ego*, while in reality it is but a dream, dreaming itself. —We only escape from this bewitchment by the moral activity of the *ego*, which feels itself a cause and a free cause, and which by its responsibility breaks the spell and issues from the enchanted circle of Maia, Maia! Is she indeed the true goddess?" (vol. ii. pp. 10-11).

Nothing could be clearer than this exposition of the idealistic view of the world, and, when we read it, the mystery of Amiel's non-success as a teacher increases.

Amiel did not lack in worldly wisdom. His saying, "Nothing is more characteristic of a man than the manner in which he behaves towards fools"—Carlyle's majority of mankind and Hobbes' *stulti innumerabiles*, is one to be thought over. The man of ability who thwarts or browbeats these otherwise estimable individuals will repent it. Rather let him use them as the ants do the aphides, patronising them, taking their produce and favouring their growth! a truly Machiavellian advice.

Amiel was deeply and truly religious in the best sense, and did not take the gay contemptuous view of Renan. Renan's remark, on this aspect of Amiel's nature, would indeed have shocked him. "He speaks of sin, of salvation, of redemption and conversion as if these were realities. He asks me what does M. Renan make of Sin? Eh bien, je crois que je le supprime."

With all our admiration and love for Amiel, we must not forget that he neglected duty. We need not say of him as Stevenson said of Thoreau, that he was a skulker, but Amiel should at any rate have recognised that in spite of his hostile environment and his Buddhistic intellect, it was his duty to give his best to his men, and doubtless they would then have responded to his influence.

There is much in common between Thoreau and Amiel. Both were phthisical in constitution, meditative and self-concentrated, entranced by Nature, abhorrent of actual and routine civilized methods,[a] and therefore their apparent failure from the smug worldly point of view. They heaped up neither wealth nor worldly honours during their lifetime, but their influence is now a great and increasing one on all who think and do not follow the superstition of narrow convention.

One word of caution may be given as to Amiel. A study of his *Journal* is apt to be enervating, and the man who yields to its

[a] Amiel's remark that "action is but coarsened thought" is characteristic.

influence too much may suffer. Amiel has not the stern helpful life-philosophy of Stevenson.

We have now to try to understand the psychology of the men we have been considering. Rousseau must be left out: he is too colossal in his vices and political power to be analysed by ordinary men, and it would take a bold writer to follow where Morley has led the way. Let me attempt the psychology of Pepys and Amiel.

The first thing is to explain the self-analysis of the *Diary*. Both Pepys and Amiel took a detached view of themselves. They found out that under certain circumstances they did a definite thing, and that often their power to will yielded to their inborn mental mechanism. They thus felt that their power of action seemed predetermined, and, interested in this, they began to observe themselves. Pepys knew that given certain conditions and surroundings, gallantry was likely to follow; and Amiel soon discovered that however much he felt inclined to do definite and original literary

work, however anxious to please his anxious friends by following their advice, he would almost certainly not put pen to paper for public perusal. It is curious that he published his poetical effusions, which have no real ring; but here again we have a common human weakness, the desire to excel in some subject in which one is mediocre, and the neglect of the source of one's real strength.

Amiel thus analysed himself and his nature. Freed from responsibility he gave his opinions freely on many of the greater problems of humanity, with a penetration and power that cannot be overestimated.

Pepys left his *Diary* to his college, Magdalen, perhaps in the hope that its ultimate publication would vindicate his memory in official matters, and as for the little details of scandal about himself—*les petites indiscrétions*—he had no direct posterity, and, after all, would it matter after his death! His motives may thus have been much the same as those that led to the publication of Prince Hohenlöhe's *Memoirs*, a desire to vindicate his career.

Can we in any way account for such characters as Rousseau, Pepys, and Amiel? This cannot be done accurately and scientifically, but M. Taine has thrown out an idea which is suggestive. He speaks of Napoleon as one of the Medici come to life: one of the ancient iron men, supreme in will and intellect, who comes into the world's politics suddenly and leaves no apparent successor.

Thus in Pepys, we recognise one of the old Roman consuls—great in administration, fearless in their duties, whose virtues Gibbon reveals in his text while, ostrich-like, he hides their peccadilloes in the Latin of his footnotes.

Amiel, on the other hand, is one of the Buddhists in his nature. Strange that we should have this in a French intellect, where the tendency is to clear-cut results, where logic is everything and the rebellious facts are clipped to the wished-for conclusion. Amiel in all this was, in his life, the antitype —irresolute, contemplative, intoxicated with thought, scornful as to actions—as out of place in this world as a bonze in the House of Commons.

Heredity has its laws of which we know little yet; but the one we know least of is that regulating the appearance of men of genius or of such belated dwellers on this planet as Pepys and Amiel, the literary atavists of Evolution.

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Notes

[1] The precursors of Darwin are thoughtfully and ably considered by H. F. Osborn in his *From the Greeks to Darwin* (New York, Macmillan & Co., 1894), and it is shown that the Greeks, especially Empedocles, shadowed forth Evolution and the survival of the fittest. The philosophy of the Greeks carried them further, in pure speculation, than any other nation, but they had a philosophy without facts. It is astonishing how many minds struggled with the idea of Evolution, but it is none the less true that Darwin first gave it a body by his facts.

[2] The conspicuous laugher-down was Wilberforce, the Bishop of Oxford (1805–73) who, primed with facts by Owen, had his Waterloo at the meeting of the British Association at Oxford in 1860. The whole circumstances are related in Huxley's *Life* (vol. i. pp. 179 *et seq.*), and are still worth recall. Wilberforce's coaching, eloquence, and wit made him a formidable antagonist. He exposed his flank, however, when he asked Huxley, "Was it on his grandfather's and grandmother's side that the ape ancestry came in?" Huxley's reply was merciless and complete: "If there were an ancestor whom I should feel shame in recalling, it would rather be a *man*—a man of restless and versatile intellect—who, not content

with an equivocal [a] success in his own sphere of activity, plunges into scientific questions with which he has no real acquaintance, only to obscure them by an aimless rhetoric, and distract the attention of his hearers from the real point at issue by eloquent digressions and skilled appeal to religious prejudices." [b]

[3] Far from considering Darwin rash in his views and in the aim of his researches on the *Origin of Species*, it would be more accurate, now we know what they have led to, to describe them as modest and unassuming.

[4] *Darwinism.*—What Darwinism is and involves may be disputed, but on this point Poulton in his *Essays on Evolution*, p. 95, considers the factors to be individual variation, the fact of heredity, and the struggle for existence. Alfred Wallace, the eminent naturalist, shares with Darwin the credit of the theory of the Origin of Species.

[5] The transmission of acquired peculiarities from soma to gametes seems to some able observers to be demonstrated, and Eimer's *Organic Evolution* may be looked into for this (Cunningham's translation). It seems to have interested all ages, and Aristotle, quoted by Osborn, wrote: "A case is also reported from Chalcedon, in which a father had been branded with a letter, and the same letter, somewhat blurred and not sharply defined, appeared upon the arm of his child." [c]

[6] *Determinants: Determinates.*—These are useful terms in discussion, but must be considered as merely convenient terminology. The "determinants" are in the chromosomes of the gametes and zygote, and are causal to the structures and powers of the developing

a Huxley stated that he did not remember using the word "equivocal."

b Op. cit. p. 185.

c Op. cit. p. 46.

organism. The organism's tissues and organs are spoken of as the "determinates," the results. Thus terminologically the "determinants" in the germ-plasm of the gametes and zygote are "causal" to the determinates. What the determinants are in essence, we do not know. At present they are supposed to be in the "chromosomes" of the nucleus of the cell, and to carry heredity (*vide* Fig. 1, p. 17).

[7] The question of the origin of the gametes is the most important of all in embryology, and is fiercely disputed. Up till recently the view held was that of Waldeyer of Berlin, a most eminent anatomist, and one whose investigations in embryology have been of the greatest value. Waldeyer examined the developing ovary of the chick. In such, and in mammalian embryos, there are temporary kidneys, known as the Wolffian bodies, quite different in their fate from the ordinary or permanent kidneys man has. They represent the kidneys of some fishes. It is on the surface of the Wolffian bodies, in a special area of the modified epithelium (the germ-epithelium) covering them, that the primitive germ-cells are found. The ovary develops in connection with this germ-epithelium, and ultimately in the substance of the ovary the primitive germ-cells, now the female gametes or ova, are found. Probably the connective tissue of the ovary has grown up and snared them in, as Dr. Foulis of Edinburgh, an able investigator and medical man, was one of the first to show. The question arose, How did these primitive germ-cells get into the germ-epithelium? Waldeyer gave the only answer possible at the time of his investigation, namely, that they were derived from the germ-epithelial cells. Now that we know that the gametes have the combined unit-

characters of heredity between them, we see that a purely somatic or body-cell, not of a high type, cannot possibly become a gamete, male or female, as these are a microcosm of unit-characters. Juxtaposition of cells is no safe criterion as to their origin.

The second view is a remarkable one, but will probably be accepted in time. At present it is the Cinderella of Embryology, despised and flouted. This view is that the gametes are derived from an early division of the zygote. The history of this view is remarkable. Owen in 1849 made the greatest observation of all the many remarkable ones that came from his pen, when he stated, almost as a general proposition,[a] that the germ-cells were set aside for reproduction before the development of the individual began. It was only in 1891 that Eigenman described the precocious "segregation of the germ-cells," and Beard of Edinburgh has since then devoted special attention to the subject. Briefly, Beard has shown that in the embryo skate, properly prepared, sectioned, and stained, the primitive germ-cells derived from an early division of the zygote can be found travelling by the yolk stalk back towards the *Anlage* or "fundamental basis" of the embryo, towards the Wolffian ridges, into whose epithelium they will pass, and ultimately form the gametes of the sexual glands. They have thus been derived from an early division of the zygote, and then pass into the embryo, ultimately mobilizing on the future sexual glands. This view leads to more important conclusions than can be considered here, and Waldeyer truly says, "Die Folgerungen aus dieser Lehre von der Continuität der Geschlechtszellen sind fast unabsehbar fur die gesamte Biologie."

[a] See his *Parthenogenesis*, London, 1849, p. 5.

[8] The startling conclusions of Loeb and others, that immersion of certain invertebrate unfertilized eggs in simple salts can lead to an apparent fertilization result, seems to me to lack the proof that such eggs are really not zygotes, *i.e.* derived from the primitive germ-cell mass with insufficient reduction, and are therefore not gametes.

[9] There is a remarkable law in relation to the embryo and the developed adult, which has been greatly emphasized by Haeckel, and has therefore been termed "Haeckel's Law," although von Baer, Müller, and Darwin share the credit. It is briefly, that an embryo in its development recapitulates in an abbreviated form many of the phases of its race history, its ontogeny repeats its phylogeny. Thus the human embryo, in the temporary gill-slits, and in the stages of many of its organs, has developmental stages which are permanent in lower organisms. This was put picturesquely but somewhat inaccurately by Milnes Marshall, who spoke of an embryo as thus climbing its ancestral tree!

In the development of the gametes from the early separated primitive germ-cell mass, we may read-in an expression of Haeckel's Law in that we have here the reminiscence of the amœba bud.

[10] It is generally held that a single male gamete and a single female gamete form the zygote. Evidence, however, is accumulating that the sex gametes may be each double, and it may be that one is a sex gamete, containing *inter alia* the sexual determinants; the other a non-sex gamete. Thus a male sex gamete and a non-sex female gamete are necessary to give a male zygote: while a female sex gamete and a male non-sex gamete give a female zygote. Thus sex is definitely settled at

fertilization, and we get the approximate 50 per cent. of the sexes.

[11] *Vide* Lowell, *Mars the Abode of Life*, A. and C. Black, 1909.

[12] "Before the segmentation of the egg had at all advanced, before what embryologists had called the blastoderm was more than incipient, two cells were observed to be set apart externally (these had nothing to do with the polar bodies seen in most ova at the maturation). The development proceeded apace, but the isolated cells took no share: they may be presumed to have retained intact the characters which they received when first divided off from the ovum; at a certain stage, however, the isolated cells sank inwards, took up an internal position, and became the rudiments of the reproductive organs. Here then, at an early stage, before differentiation is marked, the reproductive cells are set apart. They must, therefore, preserve much of the character of the parent ovum, and hand on the tradition intact by continuous cell generation to the next generation."[a]

[13] *Vide* Farmer and Moore. The gamete has only half the number of chromosomes of a body-cell. This is due to the fact that prior to fertilization both male and female gametes throw off certain determinants from their chromosomes, the so-called polar bodies, *i.e.*, are reduced or rendered incomplete *quâ* development into an adult. Their union makes up the number of heredity determinants necessary for the complete zygote. The determinants thrown off must vary, and thus we get a variation zygote. The great cause of variation is thus intrinsic, and due to this reduction.

[a] *Vide* Geddes and Thomson, *Evolution of Sex*, revised edition, p. 98. The organism considered here is a fly.

[14] Mendelians owe a great deal to the zeal and energy with which Professor Bateson and his pupils have emphasized the importance of Mendel's work, and I have to express my great indebtedness to his last work on *Mendel's Principles of Heredity* (Cambridge: at the University Press, 1909). The literature is full, and careful pictorial illustrations of various cross-fertilizations given.

[15] Instructions as to cross-fertilization are given in Punnett's *Mendelism*, p. 82.

[16] Barclay (1759–1826) was an anatomist in Edinburgh at the time of Monro Secundus. He had been trained for the Church, but, according to his biographers, never held a charge. He was what is termed in Scotland a "stickit minister."

[17] The Cyprian variety of bees is said to be the most thorough and speedy in drone destruction.

[18] *Vide The Lore of the Honey-Bee*, p. 33 (Tickner Edwardes, Methuen & Co., London, 1908).

[19] *Vide* Langstroth, *The Hive and Honey-Bee*, p. 17 (Dadant & Co., 1908).

[20] For an interesting description of an observation bee-hive in the Temple Chambers, London, see *Spectator* for 18th September, 1909 (S. L. Bensusan).

[21] *Vide* Hoffer's interesting work, *Die Hummeln Steiermarks; Lebensgeschichte und Beschreibung*, 1882; also Eimer, *Organic Evolution*, p. 270.

[22] It is possible that the queen lays only fertilized eggs, a male zygote producing drones, a female zygote producing queens or workers. The queen-egg may need special food; under scanty food the worker-egg may lose some of the determinants for its genital tract. The production of the worker-bee is, I believe, due to

some intrinsic change in the worker-egg, as it is not hereditary owing to its sterility. The whole question is, however, still a mystery.

[23] Darwinism was always strongly supported by most American biologists, and America is still a stronghold of modified Lamarckism, Neo-Lamarckism.

Glossary of Scientific Terms

ALLELOMORPHS. — Qualities like tallness and dwarfness, when taken as selected and contrasted characters in a crossing experiment, are allelomorphs.

ASCARIS MEGALOCEPHALA. — The round worm of the horse's intestine. The zygotes of one variety contain four chromosomes; its gametes two. This makes changes in them easily studied microscopically.

BIOMETRY.—Biometry is concerned with accurate measurements of "organs," their relations and the laws governing their occurrence.

CENTROSPHERE.—A minute structure in a cell undergoing division of its chromosomes. It seems to regulate these divisions.

CHROMOSOMES.—The deeply staining rods or structures in the cell nucleus (Figs. 1 and 2) of varying shape, according to the way they are cut in the section, or the variation changes have occurred in them (Mitosis: Karyokinesis).

DETERMINANTS.—A term we owe to Weismann. He uses it as equivalent to something causal in the chromosomes of the gametes and zygote, to the results in the adult organism.

DETERMINATES.—A term due to Weismann, and expressing the result in the adult to which the determinants are causal.

DOMINANCE in a unit-character means *inter alia*, in my opinion, that when crossed with a contrasted unit-character it appears first in F^1 in the soma of the plant or animal.

DOMINANT, IMPURE, means that the dominant and recessive qualities considered, are in the propagative part, but only the dominant of the allelomorphs in the soma.

ENGRAM.—The record in the nucleus of a somatic cell which Semon's Mnemic theory supposes can be transferred to the sexual gland or so affect it that it acts causally, *i.e.*, transmits the structure or function of this in progeny.

FILIAL REGRESSION.—Galton's statement that, for instance, tall parents do not have equally tall or taller children. The tendency is for the offspring to go back to the average population height, a result of Quetelet's law.

FREQUENCY POLYGON.—The curve given when a sufficient number of measurements of an organ are plotted out (*vide* p. 85).

GALTON'S LAW is that the parents give, in Heredity, the offspring each $\frac{1}{4}$, the grandparents $\frac{1}{16}$; $\frac{1}{32}$ comes from each great-grandparent.

GAMETE.—The egg or spermatozoon. The roe of the fish is made up of eggs; the milt, of spermatozoa. There are probably two kinds of eggs, sex and non-sex, and two kinds of spermatozoa, sex and non-sex.

GAMETIC PURITY.—*See* Gametic Segregation.

GAMETIC SEGREGATION, THEORY OF, means that in a crossing experiment where one or more pairs of allelomorphs are employed, the contrasted unit-characters are each pure in a gamete — purity of the gametes.

ID.—Weismann's term for the group of determinants necessary to form an organism.

MATURATION OF THE OVUM.—This occurs in the primitive germ-cells when they reduce their chromosomes to one-half prior to fertilization. The chromosomes divide in a well-known complex manner in the ovary before this (*vide* pp. 17 and 40), and I have urged that all this is a rearrangement of the unit-character determinants in the chromosomes, according to the law of frequency of error.

MNEMISM. — Semon's theory—an attempt to connect somatic variations due to outside influences with the sexual glands and thus make them causal.

MUTATION.—De Vries' term for the sudden formation of a species, as in *Oenothera Lamarckiana.*

PANGENESIS.—Darwin's theory, by which he attempted to get a variation in the soma, from environment, into the sexual glands. He supposed that gemmules from the variations in the soma were carried by the blood to the sexual gland and were thus able to transmit the variation.

PRIMITIVE GERM-CELL MASS.—The part of the early zygote set aside to form the future primitive germ-cells from which the gametes are ultimately derived.

PRIMITIVE GERM- or SPERM-CELLS are due to multiplication and division of the primitive germ-cell mass. They travel through the early developing organism to the sexual gland and become embedded there. They are germ-cells in the female, sperm-cells in the male.

PROPAGATIVE PART.—In the zygote, the primitive germ or sperm-cell mass, and in the adult the sexual gland.

RATIO, MENDELIAN.—The ratio 1 : 2 : 1 of frequency in which unit-characters sift out.

RECESSION means that a contrasted unit-character does not appear in the soma of the plant or animal till F^2, and then only in a certain proportion.

SEGREGATION, LAW OF, strictly means the sifting out of unit-characters *in the plants of combined generations* in the Mendelian ratio, 1 : 2 : 1. I have urged that the unit-characters sift out in the zygote and that the ratio is not due to gametic combination but to zygotic segregation, the determinants segregating according to the law of frequency of error.

SOMA is the animal's or plant's body, apart from its propagative part.

UNIT-CHARACTER.—This means that qualities or functions in an individual may be considered autonomous. The determinants of the unit-characters are in the gametes and zygotes. Unit-characters do not blend but sift out unaltered in certain ratios. They interchange after the gametes unite, between the propagative and somatic parts of the zygote, according to the law of frequency; tallness, dwarfness, colours, shapes of organs, mental abilities, and so on are all regarded as unit-characters.

ZYGOTE.—The fertilized ovum due to the union of the gametes. Probably a sex ovum and a non-sex spermatozoon unite to form a female zygote; a sex spermatozoon and non-sex ovum to form a male zygote.

ZYGOTIC SEGREGATION means that the unit-characters are segregated out in the zygote by the law of frequency.

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